Science Education

TOWARD MORE EXACT KNOWLEDGE

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The development of the study of our natural sciences has been one of great significance in the process of education. This grows out of the fact that science by its very name constitutes a search for exact knowledge. Education that is not based upon exact knowledge sooner or later fails, and fails most disastrously in a democracy.

Over and over it has been emphasized that a democracy can function only through an educated and enlightened citizenry.

Science recognizes the importance not only of gathering together facts, but of drawing conclusions with reservations. Science recognizes that there will be very definite differences of opinion that will necessarily follow the human observation of any group of facts.

There is a close relationship between the progress of science, and of education and of democracy, and of civilization. I think it is fair to assume that the progress comes in just about that order. Science is never satisfied; it continues to test all of our factual knowledge discarding those statements that do not endure the tests and preparing modified statements. Then education takes up those facts and studies their various inter-relationships and devises plans for assisting all those who come within its reach to arrive at conclusions and adopt plans and programs that will make the most efficient use of these facts.

Democracy then goes still farther and endeavors to translate those facts and viewpoints into human relationships that will be accepted by the majority. Democracy desires truth; democracy desires information; and democracy sets up the machinery by which from time to time intelligent compromises are effected. Civilization as we think of it has made its greatest advances in democratic countries.

Science is continuously living and growing as new researches are made. Education is alive and growing in so far as it keeps abreast of the new results of scientific studies of all kinds. Democracy is alive and growing in so far as it gives due consideration to all these facts, conclusions, and theories from time to time. One of the most significant phases of democracy grows out of the constant re-survey of facts, of re-testing theories, and of modifying programs of government and social relationship as occasion may require.

One or more of the natural sciences have long been regarded as essential parts of a high school curriculum, either as an elective or as a required. There are many good reasons why this should be an essential part. In my own classes I have often started a discussion with this question: "Will you name one article that you eat, in the production of which some phase of science has not formed an important part?" Or sometimes I have used this question: "What cause of happiness in your life may be traceable to something in which science has not made a major contribution?" Or: "What convenience do you have in your home that has not been evolved on the basis of certain scientific principles or studies?"

These questions always stimulate discussion, and thought and appreciation of the part that science has played. It is my opinion that we ought to have more of this sort of thing and that we can well afford, if necessary, to let some of the fundamental law concepts take the background while we stress these points of view.

An appreciation of science and the part that it plays is an essential part of the enlightenment which our school system should provide and which goes much farther than the knowledge of facts and principles.

We often refer to current times as a "machine age." The machine age has been brought on largely through the development of scientific principles and their practical application. We have found so many ways to do work by machines that we have made unconsciously great contributions to the development of unemployment. We need to direct our attention toward these scientific developments that will provide new types of employment, whether that employment be for gain or recreation.

Very little has been done in definite scientific planning for recreation, and we need to give it much attention as a part of our schools.

The Science Department of the National Education Association is now making a study of the place of science at all grade levels in our school system. They have recognized the importance of science in every grade, not merely the high school grade. The Department has created a nation-wide committee on the teaching and content of courses at all grade levels. In order that this may be made as practicable as possible, the Department has invited each of our leading scientific organizations to name a member on the Advisory Committee. Almost every one of the scientific organizations has responded in a most satisfactory way.

Our courses in science have been modified in a scientific manner from time to time as new discoveries have been made. In many cases, however, they have not been modified to meet the changing needs of the students in our high schools. There is much that we can do, and should do, toward providing those courses in science that will be helpful in understanding and appreciating science by those who do not plan to give their lives to the subject of science teaching or research or mastery of scientific principles.

This concept of a revision of courses for those who are not going into science as a life work must not be construed in any way as more important than the continuance of those courses that are primarily designed to present the exact principles of the various sciences.

Students at all age levels can get something out of a continual restatement of facts that bring out the importance of the exactness of scientific knowledge and use. With some, mathematical calculations that enable the astronomer to tell exactly the second at which an eclipse will occur will be very significant. To others, the importance of the exact size of the parts of a watch or of an automobile engine will appeal. To others, the photo-electric cell and its uses in opening doors and in measurement of light for photographic purposes will have its appeal. In some cases the basis of appeal will be an interest in and an appreciation of, without any strong desire to acquire, the exact knowledge and skill implied, and in other cases we would find just the reverse.

All of this illustrates one of the things which we must continually emphasize in our American type of education—the freedom to learn; the freedom to search for new scientific facts and truths; and the freedom to apply those scientific facts and truths to individual and social ends. We must bear in mind that many of our people will never do more than appreciate; but to appreciate the results and appreciate the right to allow that freedom to bring results is one of the most essential characteristics which we must always provide for, preserve, and defend in our school system to the end that it may do its full share in developing an educated and enlightened citizenry for the preservation and elevation of our American democracy.

AN ANALYSIS OF THE MENTAL REACTIONS OF CHILDREN AT DIFFERENT GRADE LEVELS TO CERTAIN LIVING ANIMALS

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It is generally conceded that children are interested in living animals. The question of the introduction of a study of animals into the school curriculum has engaged the attention of educators. As far back as 1835, C. Dewey [1] advocated the introduction of Natural Science into the course of study of the common schools. The observation of the animal itself was a step forward from the days of Comenius [2] who had long before that time pointed to the value of an illustration to accompany the printed word.

Mau [3] experimented with regard to the relative interests of children in physical and biological nature materials in the Kindergarten and Primary Grades.

Mau draws the following conclusion. "It is clear that there must be an increasing importance given to animal life in the organization of nature study work." In the study made by Finley [4] he concludes that "the same subject matter in elementary science is suitable to both sexes."

Downing [5] investigated the interests of children as indicated by their questions sent to the periodical *Saint Nicholas*. Many of these children were older than those with whom Mau worked. He found that the interest in animals far surpassed that in plants or physical environment. "Of the total, 20.6 per cent concerned plant material, 61 per cent animal material, 11.6 per cent physical material and 1.8 per cent miscellaneous." An important difference between the questions investigated by Downing and those obtained by Pollack, Craig, and others, is the fact that they were not stimulated by a questionnaire. Downing believes that the native interest of the child in the material used for instruction, is one important criterion in the selection of subject matter.

Trafton [6] in his study to test the children's knowledge of animals and plants, and second, to see Nature from the child's standpoint, examined the papers of about one thousand children in the four upper grades of the Passaic, New Jersey, Public Schools. The questions sent out to the children dealt with the children's knowledge of individual animals and their noticeable characteristics, the children's likes and dislikes among the animals and the children's conception of animal intelligence.

Trafton discovered "a limited acquaintance of the children with the wild plants and animals." He finds "the lower grades much more impressed with color and size of the animals." He thinks that the fact that "the upper grades noted activities more is without doubt an index of the children's knowledge. The younger ones were restricted largely to a knowledge of the mere appearances, while the older ones had been learning more about the habits of the animals; and that the children as soon as they came to know more about animals showed the tendency to be more impressed by their habits and other activities."

[1] C. Dewey. *American Annals of Education* V (June–July 1835), pp. 248–253, 304–311.

[2] J. A. Comenius. *Orbis Sensualium Pictus*, translated by Charles Hoole. New York: T. and J. Swords, 1810.

[3] L. E. Mau. Nature Study Review VIII (November 1913), pp. 285–291.

[4] C. W. Finley. *School Science and Mathematics* XXI (January 1921), pp. 1–24.

[5] E. R. Downing. *Nature Study Review* VIII (December 1912), pp. 334–338.

[6] G. H. Trafton. *Nature Study Review* IX (September 1913), pp. 150–160.

Finley [7] conducted an experiment to see "if any principles might be obtained which would lend themselves to a definite arrangement of the materials used in a course in elementary science, or to see if there are any principles by which such a course might be effected." He used three different schools: A—a school in Chicago, where the parents were willing to pay for the school privileges of their children; B—a school in Gary, Indiana, where there was an unusually large number of nationalities; C—a ward school in one of the suburbs of Chicago. Later he repeated the experiment in four additional schools: D—a school in the congested Jewish district in Chicago; E—a composite made up of seven rural one-room schools in Coles County, Illinois; F—a school in Goshen, Indiana, a small residential town; and G—a school in De Kalb, Illinois, "where there is a very close cooperation between the State Normal School located there, and the city schools."

He says "the plan of the experiment called for an animal not known by the pupils. The form selected, which was thought would fill this requirement was the commonly called 'mud-puppy,' or 'water dog' (Necturus maculatus) which grows to be more than a foot long. The one used was an unusually large specimen." This animal is also known as mud eel, water newt, gilled salamander and water lizard.

The mud-puppy was brought into the class room during the regular school hours in three inches of water in a large rectangular glass acquarium. The pupils were permitted to view the animal in groups of seven for three minutes without discussion. Then they returned to their seats and in writing, asked all the questions they desired to have answered about the animal. The animal was taken from the room after all had viewed it.

The papers were then collected and a short talk given on the animal. The questions were later classified by Finley into about nineteen categories. These categories are Identification, Classification, Environment, Food, Life History, Adaptations, Geographical Distribution, Use, Evolution, Abundance, Habits, Dangerousness, Movements, Function of Parts, Structure (except Gills), Teleological Questions (what-why questions), Gills, Size, Color, Sex, Enemies.

In reviewing his findings he states: "there is an indication of a variation in the interests of pupils in animals in the different grades. Practically all the pupils wanted to know the name of the animal and to know what the structures on the neck were. With the exception of the first and second grades most were interested in its environment and food."

While Finley "does not believe that interest is the only basis to be considered in the organization of a course of study, he does believe that it is one of the essentials."

E. Laurence Palmer [8] noted that the Cornell Rural School Leaflets had dealt with physical science to such an extent that there was an abundance of reading material in that field. There was practically none in the sphere of biological science. He decided to plan some leaflets on biological subjects. To that end he sent a leaflet and a questionnaire to many rural teachers actively in service, calling for questions that were being asked by their pupils.

"The returns showed that the larger per cent of questions were asked about phases of the work not yet appearing in the leaflet." The questions, therefore, could not have been motivated by that publication.

Craig [9] used children's interests in science materials as shown by their questions,

[7] Finley, op. cit., p. 2.

[8] E. L. Palmer. *Nature Study Review* XVIII (January–February 1922), pp. 23–30.

[9] G. S. Craig. *Contributions to Education* No. 276. New York: Bureau of Publications, Teachers College, Columbia University, 1927, pp. 28, 29, 31, 42.

in developing a course of study in science for the Horace Mann Elementary School. "Care was taken to avoid setting up any factor that might in any way influence the children in stating their questions." The directions to the children were:

> We want to know the questions in science and nature study which have interested you the most and which you desire to have explained. Please write these down on this sheet of paper.

"The technique used in collecting questions differs in this respect from that of several other studies of children's questions. The questions were collected from so many different classrooms that the previous instruction in any one could not have influenced the final results to any great extent."

Craig's study included children in all grades in ten different schools, private and public, in different sections of the United States. Craig secured a total of 6,806 questions from these children. He found that "an interest in animals was among the leading interests of the children. The word bird heads the list of nouns occurring most frequently in the children's questions."

In May 1929, an experiment was carried out by Stevenson [10] in the Demonstration School of the San José State Teachers College at San José, California, which revealed some interesting findings about children's nature interests. One hundred and nineteen children in Grades IV–VI, inclusive, with an age range of ten to thirteen years participated in the experiment.

The purposes of this experiment were to discover whether children's nature interests really lie in nature materials, to determine in which fields of nature study children are most interested, and to ascertain which objects in each of the nature-study fields are most interesting to children.

[10] E. N. Stevenson. *The Elementary School Journal*, Vol. V. No. 32, December 1931, pp. 275–284.

Mrs. Susan Isaacs [11] in her "garden school" exposed young children to an environment rich in insects, spiders, worms, snails, toads, frogs, rats, mice. In addition there were white mice, caged rabbits, a hen and chicks, and cats. There were numerous flowers, vegetables, and trees planted on the grounds.

The records of the activity of these young children who were two to seven years of age show that a large part of this activity resulted from "looking inside" dead animals; it was by this phrase that the children referred to dissection. Children of the ages four to ten years are on the whole more actively and spontaneously interested in animals than in plants.

All these studies were undertaken largely for the purpose of assisting in curriculum construction. They reveal little, if anything, about the mental reactions of children to living animals.

While the interests of children in the study of animals has been recognized for over a century, no study of these interests reveals to us the psychology of learning involved in the use of living animals as materials of instruction. Therefore it seems essential that we investigate the nature of the mental reactions of children of different ages to selected living animals in order to provide a psychological basis for that part of the curriculum that aims at developing in children an understanding of life through the use of living animals.

STATEMENT OF THE PROBLEM

The problem of this study then is An Analysis of the Mental Reactions of Children at Various Grade Levels to Certain Living Animals.* An attempt will be made to answer the following questions:

[11] S. S. Isaacs. *Intellectual Growth in Young Children*. New York: Harcourt, Brace and Company, 1930, pp. 158–213.

* Further details on the problem, procedure, and findings are given in a doctoral thesis, New York University, 1939.

(1) What kind of mental reactions are apparent when children of different grade levels study certain living animals?

(2) Are there any general patterns in their mental reactions?

(3) Is there any sequence in complexity in their reactions with subsequent observations by the children?

THE PROCEDURE USED IN COLLECTING DATA

1. Living vertebrate animals are available for study by elementary-school children in the Vivarium (animal room) in the Washington Irving High School, New York City. Nine different species of these animals were used for this investigation. The living animals studied were a robin, a goldfish, a honeybear (kinkajou), a capuchin monkey (known as a sapajou), a raccoon, a skunk, a gopher snake, a painted tortoise (land turtle), and a woodchuck.

Children from five different grades in the elementary schools in one section of New York City were selected to participate in this study. Each child devoted his entire attention to just one animal. Eight to ten children in each of the five different grades made observations on the same animal. Each of the nine animals was studied by forty to fifty children. Four hundred children were involved in this project.

The children made three visits on successive days. Each child studied only his own particular animal for the entire time on each of these visits. Each visit lasted for fifteen minutes on each day. The children were told not to talk to any one about their animal during this experiment, but to write any question or anything they wished to say on the card provided for this purpose. All questions not answered by the children themselves were answered by the teacher at the end of the last visit.

The younger children, who could not write so well, expressed their thoughts orally to some person competent to record them. All this recording was done while the animal was in the presence of the child.

The children observed their particular animal in small groups of four or five but each child recorded his observations individually, without referring or listening to any one else. There was no discussion of these observations in the home school during the experiment.

2. A record was kept of the behavior of the animals at the time the children were observing them.

3. Conditioning of the children by previous acquaintance with the animals was investigated by having them write answers to the following questions:

Have you seen this animal?
How often?
Where?
What was it doing?
Have you seen a picture of this animal?
Have you read about this animal?
Have you been told anything about this animal?
What do you remember of what you read about this animal?
What do you remember of what you have heard about this animal?

4. The records of the children's statements and questions were carefully analyzed to determine answers to the following questions:

(a) What kinds of mental reactions are apparent when children of different grade levels study certain living animals?
(b) Are there any general patterns in their mental reactions?
(c) Is there any sequence in complexity in their reactions with subsequent observations by the children?

STATEMENT OF THE FINDINGS

A careful analysis of the records of the statements and questions of these pupils reveals the following findings:

1. The chief interests of the children center around

(a) Food and drink and eating
(b) Actions of the animal
(c) Points of structure of the animal
(d) Color of the animal
(e) Resemblance of the animal to some other animal or to some inanimate object

2. These children use the question form for the expression of their thoughts less than they do the predicative form. Of all the remarks made, the questions constitute only forty-two per cent. Different groups vary considerably; from six to eight—seven per cent of their statements are questions. Even in the same grade there is a marked variation; e.g., in grade 3B² the questions form twenty-eight per cent of the total remarks while in grade 3B³ the questions constitute sixty per cent.

The amount of questioning varies with the particular animal studied. The following table shows the per cent of all the remarks made about each animal that are questions.

PER CENT OF ALL REMARKS THAT ARE QUESTIONS

Animal	Per Cent
Bird	30
Fish	43
Honeybear	39
Monkey	28
Raccoon	44
Skunk	56
Snake	61
Turtle	40
Woodchuck	44

There is the least amount of asking about the monkey and the bird. The greatest amount of asking is about the snake and the skunk. In some instances questions constitute 75 to 100 per cent of the remarks made by the child about the particular animal being studied. In other instances 75 to 100 per cent of the remarks are in the form of predicative statements. Three hundred and twenty of the 400 participating, i.e., 80 per cent, use either one or the other of these procedures. Forty-four of these 320 are less than nine years of age. Twenty of these 44 ask questions in 75 to 100 per cent of their remarks in each individual case. These twenty are 45 per cent of the 44. Two hundred seventy-six of the 320 are nine years of age or older. One hundred six of these 276 use predicative statements in 75 to 100 per cent of their remarks. These 106 are 38 per cent of the 276.

PER CENT OF ALL REMARKS THAT ARE QUESTIONS

Grade	Boys Per Cent	Girls Per Cent
3B²	27	0
3B³	42	62
4A¹	100	6
4A²	0	0
4B	25	9
4B¹	93	90
4B³	63	12
5A¹	100	12
5A²	0	0
5B³	83	100
5B⁴	77	59

3. All of the children carry on perceptual thinking. Some associate the animal with some other animal or some inanimate object. One hundred fifty-three of the 400 note some difference or resemblance. Fifty-nine note differences. Eighty-two note resemblances. Twelve note both differences and resemblances. There are 249 statements of either a difference or a resemblance out of a total of 6,225 remarks.

4. Only 25 pupils of the 400 attempt to solve the problems they pose. There are only 33 solutions given. The remarks made by these 25 pupils number 415. The total number of remarks made by the entire group of 400 pupils participating is 6,225.

5. There are generalizations made by 13 pupils, 4 boys and 9 girls, representing the following grades and animals:

Grade	Boys	Girls	Animal
3B²	1	0	Raccoon
3B³	0	2	Raccoon
4A¹	0	1	Raccoon
	0	1	Snake
4A²	0	1	Skunk
	1	0	Woodchuck
4B	1	0	Honeybear
	0	1	Raccoon
	1	0	Skunk
	0	1	Snake
	0	1	Woodchuck
5B³	0	1	Honeybear

There are more pupils generalizing in regard to the raccoon than in regard to any of the other animals.

6. Five per cent of the questions of these children are capable of motivating sustained mental action.

7. The sequence in complexity in their reactions with subsequent observations shows the following pattern:

The animal as a whole is considered first. There may be a reference to the actions of the animal, to its feeding, or to its structure or color as a whole, or to its resemblance as a whole to some other animal or to some inanimate object.

Then specific parts of the animal are noted. Sometimes the color of these parts is mentioned, sometimes other characteristics as size or structure; sometimes their resemblance to some inanimate object; sometimes they are compared with similar structures in other animals. There is a further differentiation in regard to details of structure of the parts already mentioned.

8. There are 82 pupils who had had no previous experiences of any kind with the particular animal they were studying. This fact was indicated by their answers to the questionnaire regarding their conditioning by previous acquaintance with the animal. These 82 therefore were studying the particular animal for the first time. Their chief interests are the same as those of the entire group. They carry on the same forms of thinking. The sequence in complexity in their reactions with subsequent observations shows the same pattern as that of the entire group. First, the animal as a whole is considered; then specific parts are noted; finally there is a further differentiation in regard to details of structures of the parts already mentioned.

9. The mental reactions at different grade levels show the following variations. In grade 3B the per cent of remarks that are questions is much higher than in grade 4A and about the same as in grades 4B and 5A. It is considerably less than in grade 5B.

The ability to note differences in the animals is considerably less than the ability to note resemblances in grades 3B and 4B. In grades 4A and 5B the ability to note differences is about equal to the ability to note resemblances. In grade 5A the ability to note differences is about three times as great as the ability to note resemblances.

The amount of problem solving attempted is greatest in grade 3B. It is a little less in grades 4A and 5B. It is somewhat less in grade 4B. There is no problem solving in grade 5A. While there are fewer attempts at problem solving in grades 5B than in grade 3B the nature of the solution is of a higher order in grade 5B than in grade 3B.

Very few children generalize in regard to the animals studied. The highest per cent of those in any grade who generalize is to be found in grade 4A; the next highest is grade 4B. There is a lower per cent in grade 3B and a still lower one in grade 5B. There is no generalization in grade 5A.

AN EXPERIMENT IN TEACHING PUPILS TO APPLY SCIENTIFIC PRINCIPLES

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That pupils should learn to apply scientific principles in their attacks upon related problems is everywhere acclaimed as a desirable outcome of courses in science. Too often instructors are content merely to explain the principle, assuming that pupils will themselves perceive its applicability when occasion arises. Experiments upon transfer, however, have repeatedly demonstrated that to achieve any substantial carry-over of this sort, the teaching itself must be deliberately directed to the attainment of such transfer.

The Committee of the Progressive Education Association on the Function of Science in Education has indicated in a recent publication [1] certain teaching techniques adapted to this end, as well as testing devices for measuring pupil progress in the desired abilities. The present article will describe an experiment making use of these procedures in the teaching of high school chemistry.[2]

SUBJECTS AND PROCEDURES

The subjects of the experiment consisted of eight classes taking first or second semester chemistry in one Oakland and one San Francisco high school during the spring semester of 1939. Each high school furnished an experimental and a control class in both Chemistry I and Chemistry II.

Preceding the experiment proper, the eight groups were presented with a list of all chemistry principles to be drawn upon in the later testing materials. As a source of these principles extensive use was made of the excellent compilation by C. M. Pruitt.[3] The pupils were asked to write out one example to illustrate the application of each principle stated. In this way it was hoped to make sure that every one would not only comprehend the principles themselves but be familiar with the particular phrasing employed.

Pretests were then administered and equivalent groups obtained at both class levels in both schools. The corrected pretest papers were returned to all alike, and ample class time allowed for careful examination and study of the results. Thereafter, the control groups continued according to the prevailing teaching procedure, with normal emphasis upon such principles as arose in the course of the subject matter. In the experimental groups more direct and intensive instruction was given in the application of these same principles. When the pre-test papers were returned, each pupil's performance was analyzed with the help of the Individual Test Analysis Blank shown on page 369. Class discussion was invited and evoked. Thereafter parts of several class periods were devoted to practice in applying certain principles derived from the kinetic theory, which played no part in any of the tests.

[1] Progressive Education Association. Commission on Secondary School Curriculum. Committee on the Function of Science in General Education. *Science in General Education.* New York: D. Appleton-Century Company, 1938.

[2] Babitz, Milton. Measuring Student Ability in the Application of Scientific Principles. Unpublished Seminar Study, University of California, August 1939.

[3] Pruitt, Charles M. *An Analysis, Evaluation and Synthesis of Subject-Matter Concepts and Generalizations in Chemistry.* New York, 1935. 176 pp.

TEST MATERIALS

Two items are here reproduced to illustrate the type of test materials employed. It will be noted that a correct response requires that the pupil not only solve the chemistry problem correctly but also be able to identify the scientific principles which underlie his solution. When used as a teaching aid, such problems might well be presented one at a time as new principles are introduced. For the present experiment, however, and in order to secure tests of adequate reliability, eight or ten such problems were combined in each of the pretest and final test forms.

Item 1

Directions: Choose the correct answer (or answers), and then indicate which listed principle (or principles) guided your choice of each. *Caution.* The listed "principles" may be incorrect.

Problem: One liter of hydrogen at standard conditions (273°A., 1 atmosphere pressure) is heated to 819°A. and placed under 3 atmospheres pressure. What *volume* is now occupied by the gas?

Possible Answers:	*Principle Numbers*			
a. 3 liters				
b. 1 liter	2	4		
c. 9 liters				
d. 1/3 liter				
e. 1/9 liter				

Problem: Which of the following is the correct expression for the number of moles in one liter of hydrogen at standard conditions?

Possible Answers:	*Principle Numbers*			
a 1(22.4) moles				
b. 1/22.4 moles	5			
c. 2(22.4) moles				
d. 2/22.4 moles				

Principles:

1. Compression heats gases resulting in increased molecular motion and pressure.
2. The volume of any gas varies inversely as the pressure if the temperature remains constant.
3. Molecules are in continual motion, which molecular motion results in heat and pressure.
4. The volume of a gas varies directly as the temperature, if the pressure remains constant.
5. One mole of any gas under standard conditions occupies 22.4 liters.
6. There are 6.06×10^{23} molecules in one mole of any gas.
7. A gram molecular weight of hydrogen (1 mole) equals 2 grams.
8. There are 1,000 c.c. in a liter.

Item 2

Directions: Choose the correct answer (or answers), and then indicate which listed principle (or principles) guided your choice of each. *Caution.* The listed "principles" may be incorrect.

Problem: When water solutions of some of the following substances are added to a solution of sodium carbonate, carbon dioxide will be evolved. The evolution of carbon dioxide from a sodium carbonate solution depends upon the following type of reaction, $2H + CO_3 = H_2O + CO_2$, or in words, the union of carbonate ion and hydrogen ion will result in the evolution of carbon dioxide.

Indicate which of the following substances will cause the above reaction, and the principle (or principles) governing the behavior of each substance.

Principles:

1. Chemical reactions may be initiated or affected, or both, by heat, light, pressure, hydrogen ion concentration, catalysts, and other factors.
2. All matter may change its physical state by absorbing or releasing energy.
3. Acids and bases are substances which in water solution ionize to give hydrogen and hydroxyl ions respectively from their constituents.
4. The exchange of the negative and positive ions of acids and bases results in the formation of water and a salt.
5. Salts of strong acids and strong bases undergo slight hydrolysis.
6. Salts of strong acids and weak bases undergo hydrolysis.
7. Chemical reactions go to completion when one of the products is a gas.
8. Salts of strong bases and weak acids give a basic reaction in water.

Possible Substances:	*Reacts* (Check, √)	*Does Not React* (Check, √)	*Principle Numbers*			
a. NaCl		√	5			
b. M_gCl_2		√	5			
c. $Al_2(SO_4)_3$	√		6	7		
d. HCl	√		3	7		
e. $Zn(OH)_2$		√	3			
f. $Zn(NO_3)_2$	√		6	7		
g. KOH		√	3			
h. NaH_2PO_4	√		3	7		

Individual Test Analysis

To determine the following factors:

A. Are the errors largely due to choice of *incorrect answers?* If so, Rules I and III a, b, c, should govern your selection of correct answers. That is, try and choose your answer with the active principle in mind.

B. Are the errors largely due to choice of *incorrect principles?* If so, Rules I and II a, b, c, d, should govern your selection of correct principles.

Rules for Application of Principles

I Ascertain the definite nature of the problem. (Read the problem very carefully.)

II a. Is the answer clearly indicated on the basis of your past experience?
b. If so, can you express the answer which you have selected in general terms?
c. How does your answer as generalized by you compare with suggested applicable principles?

III a. If the answer is not readily perceived, or if the answer which you have chosen does not seem to be fully justified by the principles, carefully check each principle in turn for its possible relations to the problem, seeking to eliminate any obviously inapplicable or incorrect principles.

b. Compare each possible applicable principle with the various answers, seeking to eliminate answers which are in conflict with the principles.

c. Having eliminated principles and answers which are incorrect or irrelevant, indicate the principles which justify the answers selected.

The reliability of the pretests, as determined by a formula specially devised for this purpose,[4] was found to be .64 for the Chemistry I form and .62 for the Chemistry II. The final tests were much more reliable, showing .82 for the Chemistry I form, and .86 for the Chemistry II.

[4] Babitz, Milton, and Keys, Noel. "A Method for Calculating the Average Intercorrelation of Coefficient by Correlating the Parts with the Sum of the Parts." Unpublished.

Analysis Chart

Test Item No.	1	2	3	4	5	6	7	8	9	10
Errors due to A										
Errors due to B										
Errors due to A & B										

TABLE I

MATCHING OF EXPERIMENTAL AND CONTROL GROUPS ON PRETEST SCORES

	N	Mean of group		Standard deviation	
		Experimental	Control	Experimental	Control
Chemistry I					
School A	16	18.3	18.3	9.9	9.9
School B	14	17.4	17.2	8.1	8.2
Chemistry II					
School A	16	21.4	21.2	7.6	7.0
School B	15	24.6	24.4	11.1	10.1

GAINS RESULTING FROM INSTRUCTION IN APPLICATION OF PRINCIPLES

The success with which experimental and control groups were equated on the basis of pretest scores is shown in Table I. The superiority of the experimental over the control groups on the final test may be seen from Table II. It will be noted that none of the differences obtained was sufficient for statistical significance. Even with the groups from the two schools combined, these differences will fall short of three times the standard error. This, however, must be attributed largely to the small number of pupils in the matched groups. The differences favored the experimental group on every comparison, and it is reasonable to suppose that larger numbers might have decreased the standard errors to the point necessary for statistical reliability.

The final column of Table II shows the extent to which the scores of the experimental groups excelled those of their respective controls. These averaged just over sixteen per cent. When it is considered that this gain was obtained by a slight difference in emphasis of instruction during a portion of only twelve class periods, there seems good reason to believe that ability in applying scientific principles may well be capable of distinct improvement with suitable teaching procedures.

Pupil reaction to this type of test and the problems presented was conspicuously favorable in both schools.

TABLE II

SCORES OF EXPERIMENTAL AND CONTROL GROUPS ON FINAL TESTS

	Mean score on final test		Critical ratio Diff./$\sigma_{diff.}$	Per cent by which experimental group excelled the control
	Experimental	Control group		
Chemistry I				
School A	13.4	12.4	0.58	8
School B	14.6	11.6	0.79	26
Chemistry II				
School A	16.4	13.9	1.06	18
School B	16.0	14.2	0.45	13

A SCIENCE TEST DESIGNED TO TEACH AND MEASURE OUTCOMES OTHER THAN MEMORIZATION OF FACTUAL INFORMATION

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The past few years have seen a determined attempt by the leaders in the field of education toward the substitution of certain broad aims other than the traditional teaching of memorization of isolated facts. Teachers in training and teachers in the field have alike expressed their ideas as to the desirability of measuring these new outcomes. They have voiced dissatisfaction with many of the standardized tests in use in the schools which seem to fall far short of adequately testing for proficiency in hearing other than that related to rote memorization.

Recognizing this situation many science teachers have experimented with tests of their own construction. An example of these is the work of Zapf [1] who devised a testing procedure which seems to measure degrees of pupil superstition before and after certain training in application of scientific thinking to common fanciful beliefs.

If teaching is to be carried out along the lines recommended by certain leaders in the field, rather than by clinging to the traditional memorization of data, it seems desirable that these outcomes should be emphasized. In an attempt to have pupils measure their attainment of certain outcomes of teaching, other than factual information, the accompanying test has been devised for use in the eighth grade. It has also been used in ninth-grade science, and probably could be adapted for use with other groups and ages.

This test was used in the Barnesville eighth-grade classes as a teaching rather than as a grading device. The procedure in administering the test was to place the test papers before the pupils with no explanation other than that contained in the paper itself. Forty-five minutes were allowed for the completion of the test. The actual scoring, which was done by the pupils, took practically as long as did the answering of the test. The manner of scoring was to allow one point for each pair of parentheses placed in approximately the proper position, and to give an extra point for the proper letter appearing in its place at the side of the error. Thus each scientific inaccuracy netted two points if properly selected and identified. A certain amount of latitude in scoring the placing of parentheses was found to be advisable.

The test follows:

TO THE PUPIL

Here is a test which I think you will find quite different from any you have ever taken. It is a story about Johnny Jones. He was quite an active boy, but sometimes he was a poor scientist. Some of his friends and the members of his family may not have been good scientists either. Whenever you find something in the story which does not agree with what you think good science means, put a pair of parentheses ( ) around the sentence or part of a sentence where you find this. Next, at the border of the paper beside the error, write in the correct letter from the following list:

S means that Johnny or some one else was superstitious.
D means that what was being done or had been done was dangerous.
O means that statements are being taken or have been taken for truth without any proof being offered.
J means something unscientific for reasons other than *S*, *D* or *O*. If you use the letter *J* be prepared to tell the class what was wrong with the story at the point where you use this letter.

Now go on with the story.

JOHNNY'S DAY

Johnny Jones woke from a sound sleep one morning and noticed that the sun was already shining in his window. Without looking where

[1] Rosalind M. Zapf. "Superstitious Beliefs." *School Science and Mathematics* 39: 54–62; January, 1939.

he was going he jumped to the floor and started gathering up his articles of clothing to put them on. Suddenly he stopped and said, "Shucks, it's Saturday, no need for me to hurry." "But it might just as well be a school day," he went on as he looked out of the window, "it's sure to rain today. Old man Smith said this was a wet moon."

Going into the bathroom, Johnny turned on the water in the lavatory and dipping his hand in the water to tell its temperature, he reached up with his other hand to turn on the electric light so that he might see better to wash. After he was through washing he started down stairs, picking up his shoes on the top step and putting them on.

Sitting down at the table he threw a pinch of salt over his left shoulder to start his luck out right for the day. His breakfast consisted mainly of a dry cereal which he knew would make him a strong man in a short time because the radio announcer had told him that this was the most wonderful breakfast food in the world.

After breakfast, his mother not feeling well, he went down to the corner store to get her some pills which he knew would be just the thing for her because they were advertised in the newspaper to cure almost anything.

Before going out to play he had to do a little work at home and today this took him down to the basement to clean up part of the winter's collection of ashes which his older brother had stored near the furnace in wooden boxes and pasteboard cartons which had been obtained from the corner grocery. He took some matches with him so that he could see his way down the basement steps and to locate the light switch which was placed close to the washing machine for convenience. He picked up the shovel from where it had been lying on the bottom step and soon had the work done.

The other boys were already playing baseball and wouldn't let him play when he first came because everyone knows that it is bad luck to start a new player during the second inning. Three is a lucky number so Johnny waited patiently sitting beside the batter until the third inning started. Playing hard all morning he was very warm when his sister called him to come to dinner, and so taking off his sweater and cap he started for home.

On the way home a black cat ran from between two buildings and across the road in front of him. Hastening to turn around, Johnny walked all the way around the block to get home, being roundly scolded for being late. It was all right, however, when he told them that he had to come home the long way because of the bad luck the cat would bring to anyone who dared to walk over the line. "Yes," said his mother, "if that had happened, who knows what more bad luck we might have had on top of the seven year's bad luck from breaking that mirror last week."

While the boys were playing that afternoon a flock of birds went over the field flying north. "Gee," said Johnny, "look at the ducks." "Those aren't ducks," said his friend Jimmy, "they're geese. I know because I know." "Well, anyway, there must be a million of them," said Johnny. They watched the birds out of sight and resumed their game. This time Jimmy's side won and he proudly showed them a good luck charm which he had just received through the mail. "Gee," said Johnny, "it works, don't it? I'll give you my rabbit's foot and fifty cents for it." "No," Jimmy said, "once you trade your luck away you never get it again." Hearing his father calling, Johnny ran home and saw that the gardener had come to plant the first part of the garden. "Better look in the almanac first, and make sure," his father said, and after looking at the almanac he sent the gardener home and Johnny back to play. "No use in planting radishes in the light of the moon," he said, "they always go to tops and never to root when you plant them that way."

It hadn't rained yet, and Johnny was beginning to think about the possibility that Mr. Smith might be wrong when a spring shower sent the boys scudding to the shelter of an awning. "There," said Johnny to himself, "that proves it."

Going home after the shower he found that the electricity was off because his father had blown a fuse in the wiring trying to fix a switch. It didn't take long to get the current on, however, because it was easy to put a penny behind the blown fuse.

After supper, his mother being no better, a magnetopath was called in to doctor her. He explained to the family that she was sick because the iron in her blood was magnetized the wrong way and that it would cost five dollars to set up his physio-magnetizer and make her well. While money was rather scarce in the Jones family, everybody agreed that they had better spend the money that way than to wait and have it cost more when her blood got worse. After the treatment and after promising that Mrs. Jones would be better by morning he left, and Johnny went upstairs in the dark and went to bed, being careful to see that the windows were closed so as to shut out the unhealthy night air which might give him malaria.

Finally after lying in bed thinking, for almost an hour, on plans for a perpetual motion machine, he went to sleep and dreamed that a dog was howling outside his window. He woke up shivering, because everybody knows that when that happens, someone in the house is going to die.

LABORATORY WORK IN ELEMENTARY GENERAL BIOLOGY IN THE SECONDARY SCHOOL *

(A CRITICAL ANALYSIS AND EVALUATION OF THE LABORATORY WORK IN ELEMENTARY GENERAL BIOLOGY IN SELECTED EXPERIMENTAL SECONDARY SCHOOLS AND IN TYPICAL SECONDARY SCHOOLS OF THE LARGER CITIES OF THE COUNTRY)

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THE PROBLEM DEFINED

This study is a critical analysis and evaluation of the laboratory work in elementary general biology in selected experimental secondary schools and in typical secondary schools of the larger cities of the country. Laboratory work includes problems or concrete experiences for laboratory study, and practices and techniques used in solving these problems. The problems for laboratory study are the actual things or events experienced in the study of biology. Elementary general biology, as here used, refers to tenth-year general biology, the first-year secondary-school course in biologic science. It may be offered, however, in any grade from the ninth to the twelfth, inclusive. It is to be clearly distinguished from advanced general biology, offered in some secondary schools. The selected experimental secondary schools represent a group in which the organization and curriculum have been devised to test some significant pedagogical theories. The typical secondary schools comprise a group of public secondary schools in cities throughout the country having a population of 100,000 or more.

DISCUSSION OF THE PROBLEM

The need for guidance in selecting content for the natural sciences has been pointed out in the *Thirty-first Yearbook, Part I,* of the National Society for the Study of Education, entitled, "A Program for Science Teaching," and by Beauchamp in *Instruction in Science,* Bulletin of the United States Office of Education. Beauchamp has stated that a major problem in the natural sciences is that of the role of laboratory work.

This study is divided into two major aspects: (1) a critical analysis of the content and teaching practices in elementary general biology laboratory work in selected experimental secondary schools and in typical secondary schools; and (2) an evaluation of the laboratory content and teaching practices in terms of the existing literature relative to laboratory work in biology, and in terms of the opinions and teaching practices of secondary-school instructors.

In biology, as in other sciences, it has become the custom in modern instruction to insist upon "problem-solving." But the problems to be solved in biology laboratory work have never been clearly defined. One purpose of this investigation is to determine the concrete laboratory experiences now being taught in elementary general biology, and to compare the concrete experiences used for laboratory work in selected experimental secondary schools with the experiences that are being used in the typical secondary schools. Experimental secondary schools undoubtedly present a variety of experiences and techniques for laboratory work in elementary general biology. This is also true for many of the public high schools. But we have no evidence as to the trend which these problems and practices are taking in these two school situations. The question of teaching prac-

* Abstract of doctoral dissertation, New York University, 1939.

tices, or techniques, for carrying out laboratory work in biology is also very much unsettled. There has been some experimental research to determine the preferable techniques, but there is no objective evidence that these improved techniques are being widely used. This study, through an analysis of the techniques now used in the two school situations indicated, reveals some of the methods by which these laboratory problems are being solved. An attempt is also made to ascertain what teachers of biology believe should be the desired content and practices for laboratory work in elementary general biology.

There is no evidence that the objectives for laboratory study in elementary biology have ever been brought together through the collection of objective data. The literature in science education reveals a variety of objectives, many of them contrary to accepted pedagogical theories. This study assembles these objectives, ranks and evaluates them through the assistance of science experts and teachers of biology, and then selects the problems and practices that teachers, who agree most closely with the experts in their choice of objectives, are using in the two school situations. These problems and practices may possibly serve as a basis for the reconstruction of the curriculum for elementary general biology laboratory work. While the laboratory work is definitely a part of the classwork, specific objectives may be attainable through laboratory work which could not be thoroughly achieved through routine classwork without laboratory experiences.

The practices and techniques used in experimental secondary schools and in typical secondary schools, as well as the opinions of teachers concerning them, are analyzed in the light of the accumulated literature in science education. This analysis reveals the trend that these practices are taking, and furnishes a basis for recommendations for concrete experiences and for practices to be used in elementary general biology laboratory work.

An examination of the literature in science education has failed to reveal any specific analysis and evaluation of laboratory work in elementary general biology in selected experimental secondary schools and in typical secondary schools. There are a large number of related studies pertaining to specific items of laboratory work in biology in the secondary schools. This investigation is largely dependent for its evaluations upon these studies. An analysis and evaluation of these two types of secondary schools indicate some trends and progress in elementary general biology laboratory work. Because such a complete analysis and evaluation has never been made, the present study seems worth-while.

PROCEDURE

Twenty textbooks in elementary biology were selected for the analysis of the concrete experiences for laboratory study. These were published between 1923 and 1935, and were among the most frequently used textbooks in general biology during this period. Of the twenty textbooks, fourteen were subjected to detailed critical analysis. These were selected because the authors listed the problems (experiments and demonstrations) as an integral part of the textbooks. In five of the twenty textbooks, no laboratory problems were listed. For convenience, the subjects of the concrete experiences were divided into five categories: (a) Chemicals and Tests for Nutrients, (b) Plant Biology, (c) Animal Biology, (d) Human Biology and Physiology, and (e) Miscellaneous General Biology. This analysis revealed the number of concrete experiences listed in any one textbook, their quantitative grouping according to the divisions listed above, and the number of textbooks in which any one problem appeared. The distribution of the experiments and demonstrations within the various categories was checked by a competent teacher of biology.

A similar analysis was then made of questions appearing in the College Entrance Board examinations, covering seventeen years (1915–1917, 1921–1926, and 1928–1935), including twenty-eight different sets of questions. The College Entrance Board examinations were chosen because they are national in scope, and are therefore more representative of the total picture of required laboratory content than any set of local examinations could possibly be.

The New York State Syllabus in Biology was similarly examined because it lists the required and optional experiments and demonstrations for biology laboratory work. It was not deemed necessary to analyze any additional syllabi, because where particular concrete experiences are required by city or State syllabi, these were indicated by the cooperating teachers.

A list was then compiled of those concrete experiences which appear in four or more of the textbooks analyzed, using the arbitrary subdivisions of biology previously mentioned. This list served as the basis for a questionnaire which was sent to a random sampling of teachers of biology in typical secondary schools and in selected experimental secondary schools. This random sampling was obtained from a list of leading teachers of biology, submitted by the school superintendents of the cooperating cities. The teachers were asked to evaluate these concrete experiences by indicating those experiences which they are teaching, and the methods by which these experiences are being handled in their individual teaching situations. The frequency of the concrete experiences in the textbooks was compared with the frequency of the same experiences in the College Entrance Board examinations and with those listed in the New York State Syllabus.

A second questionnaire was also sent out designed to determine some present teaching practices in biology laboratory work and the opinions of teachers with regard to these practices. These questions were determined after a careful analysis of the literature in science education with regard to laboratory work in biology.

A list of objectives for laboratory work in elementary biology, compiled from the prefaces of textbooks, from books on the teaching of science, and from the writings of a leading educational philosopher (John Dewey), was sent to nineteen experts in the field of science education to be ranked. Approximately one year later, the same list was again sent to these experts, in order to check the reliability of the ranks given to the various objectives. All the teachers receiving the two questionnaires mentioned above received this list of objectives, which they were asked to rank. The rankings of the teachers in experimental and typical secondary schools were then compared with the rankings of the experts. Those teachers, in both types of schools, who agreed most closely with the experts in the ranking of the objectives, were selected and their responses to the inquiries were analyzed for agreement in the choice of laboratory problems and practices. The responses made by teachers in experimental and typical secondary schools, who agreed most closely with the experts, were separately studied and compared. On the basis of all these, a group of practices and concrete experiences for laboratory work was determined.

There is literature in science education concerning all the questions asked in the blanks of inquiry. The responses to these questions were evaluated in terms of this literature for the teachers in selected experimental secondary schools and in typical secondary schools. The concrete experiences and practices were similarly evaluated.

There is much variety of opinion among textbook writers as to how laboratory work should be done. These opinions were also evaluated in terms of the literature in science education. As a result of these analyses and investigations, which clearly

indicate the trend of elementary general biology laboratory work, recommendations are made for concrete experiences and practices for laboratory study.

All nineteen of the experts filled out the questionnaire in response to the original request, and fourteen replies were received from the experts in response to the second request that they rank the objectives in order to obtain data on the reliability of the ranks given to the various objectives.

One hundred nineteen copies of the set of three questionnaires were sent to teachers in the eighty cities from which a list of the leading teachers of biology had been obtained. One hundred and seven teachers (89.92 per cent) answered the questionnaires. All the teachers in the twenty-three cooperating experimental secondary schools, located in fourteen different States, returned the questionnaires.

Although this is a rather comprehensive study of the laboratory work in elementary biology in experimental and typical secondary schools, the items chosen for study have been definitely limited to those that have been previously treated in the literature of science education. This delimitation has been made so that the literature may serve as the yardstick for the evaluations of the items studied.

SOME SPECIFIC FINDINGS AND CONCLUSIONS

1. The analysis of the fourteen textbooks in general biology revealed 224 different concrete experiences for laboratory study.

2. No one concrete experience appeared in all fourteen textbooks.

3. In terms of the selected subdivisions of biology, the 224 concrete experiences are distributed as follows: Chemicals and Tests for Nutrients, 22 (9.82 per cent); Plant Biology, 78 (35.27 per cent); Animal Biology, 65 (29.02 per cent); Human Biology and Physiology, 39 (17.41 per cent); Miscellaneous General Biology, 19 (8.48 per cent).

4. The analysis of the textbooks showed that in every instance the number of problems listed for Plant Biology exceeded the number listed for Animal Biology. In the number of concrete experiences, the mean figures indicate a two to one ratio between the two categories. Also, in every case, the Category of Plant Biology was provided with more units for laboratory study than any other of the arbitrary subject-matter divisions. The number of concrete experiences listed indicates the following order of importance of the categories: Plant Biology, Animal Biology, Human Biology and Physiology, and Miscellaneous General Biology.

5. The analysis of the concrete experiences within the College Board examination questions indicates the same relative importance of the categories.

6. The analysis of the concrete experiences listed in the syllabus for biology of the Board of Regents of the State of New York shows the following order of importance of the categories: Plant Biology, Chemicals and Tests for Nutrients, Human Biology and Physiology, Animal Biology, and Miscellaneous General Biology.

7. The experts, as a group, even after the lapse of a year, are fairly consistent in their selection of objectives for laboratory work. The coefficient of correlation between the median scores on the original and follow-up returns is $.86 \pm .05$. This coefficient of correlation is significant because it is more than six times its probable error.

8. The pooled opinion of the experts indicates that, although no exact agreement is found, certain general objectives stand out as goals for instruction in biology laboratory work. The specific objectives were generally ranked in the lower categories of desirability.

9. Objectives C, to develop the habit of weighing and testing evidence carefully and intelligently; E, to develop the habit of holding one's opinion tentatively while

seeking the truth (to realize that one's conception of truth is subject to change); F, to arouse self-activity of mind on the part of the student; P, to develop an understanding of the cause and effect relationship in the operation of natural laws; and T, to develop growth in the understanding of the interdependence of living things, and of the interaction of living things and their nonliving environment were ranked as the first five objectives by the experts and by the teachers in the experimental and typical secondary schools.

10. The coefficient of correlation between the weights of the experiences computed for the teachers in the experimental and typical secondary schools is $.83 \pm .02$. Since these weights consider both frequency and essentiality of each concrete experience, this positive and fairly high degree of correlation indicates that both groups of teachers are highly consistent in their choice of concrete experiences and in their judgment of their essentiality for laboratory work.

11. The average number of concrete experiences taught by the teachers in the experimental schools is 85.3; for the teachers in the typical secondary schools it is 76.4.

12. In the experimental schools, the mean figures reveal that there are as many concrete experiences taught by the demonstration method as there are by the individual method. In the typical secondary schools, there is a slight preference for demonstration over individual laboratory work.

13. The teachers in the experimental schools have more than twice as many field-trip experiences as do the teachers in the typical secondary schools.

14. The teachers in the experimental schools considered 63.45 per cent of the experiences which they are teaching as essential, 34.69 per cent as less essential, and 1.86 per cent as those which should be omitted. The teachers in the typical secondary schools considered 72.64 per cent of the experiences which they are teaching as essential, 26.19 per cent as less essential, and 1.17 per cent as those which should be omitted.

15. The analysis of method in terms of essentiality indicates that a slightly larger percentage of individual experiences than of demonstration experiences were classified as essential.

16. The method most commonly used for presenting laboratory directions is to have them dictated to the students by the teacher.

17. In the majority of schools the biology laboratory and recitation work are done in the same room.

18. A greater majority of experimental than of typical secondary schools have coordinated the laboratory and class recitation periods, making no sharp distinction between recitation and laboratory work.

19. The majority of both the experimental and typical secondary schools has a definite number of required experiments and demonstrations.

20. The great majority of teachers in both kinds of schools believes that a core of minimum essentials should be selected for the biology class as a whole.

21. The majority of the teachers in both kinds of schools agrees, in theory and practice, that observations of plants and animals, experiments, and demonstrations should in most cases go on at approximately the same time as classroom discussion and study of the text.

22. The majority of the teachers in both experimental and typical secondary schools indicated that they had found the lecture-demonstration method to be the most effective of the three teaching techniques under consideration.

23. The largest number of teachers in the experimental schools believed that the lecture-demonstration technique and the individual laboratory technique are about equally effective as far as student learning of factual knowledge is concerned. The

largest number of teachers in the typical secondary schools felt that students gain more factual knowledge from demonstrations than from individual laboratory work.

24. Forty-five per cent of the teachers in the experimental schools, and 43.81 per cent of the teachers in the typical secondary schools, indicated that their schools were equipped with microprojectors. The largest number of teachers in the typical secondary schools had found the use of the microprojector more satisfactory than the use of the individual microscope by students. The replies of the teachers in the experimental schools are evenly divided in favor of the conclusions that the microprojector is less satisfactory than the individual microscope, and that the two methods are about equally effective.

25. The largest number of teachers in the experimental schools has its laboratory work grow out of problems raised in class discussion—students formulate generalizations on the basis of facts gathered in the classroom, and from laboratory experiments and demonstrations. The largest number of teachers in the typical secondary schools encourages its students to arrive at generalizations on the basis of facts gathered in the laboratory.

26. The great majority of teachers in both the experimental and the typical secondary schools does not require the students to draw the apparatus with which they are working.

27. The largest number of teachers in the experimental schools has its students make outline diagrammatic drawings on the basis of facts gathered in solving their problems. The largest number of teachers in the typical secondary schools requires the students to make drawings of representative animals and plants studied in the laboratory. Nine teachers in the typical secondary schools, but none of those in the experimental schools, require the students to finish their drawings in ink.

28. The majority of teachers in the experimental secondary schools does not require the students to write the procedure of the experiments and demonstrations studied in the laboratory. The majority of teachers in the typical secondary schools does require that the students write the procedure and method.

29. The great majority of teachers in the experimental and typical secondary schools has its students participate frequently in laboratory demonstrations.

30. The majority of teachers in the experimental and typical secondary schools agrees, in theory and practice, that just enough direction should be given the student so that he can see his way clear in solving his laboratory problems.

31. In both the experimental and typical secondary schools, models and manikins were ranked highest in the teachers' judgments of their value for learning details of plant and animal structures.

32. The most frequently used textbook in elementary general biology in the experimental secondary schools is Pieper, Beauchamp, and Frank, *Everyday Problems in Biology*. In the typical secondary schools, the most frequently used textbook is Hunter, *Problems in Biology*.

33. The replies of the teachers indicate that most of the schools use basic textbooks and, in addition, many references.

DISCUSSION OF THE PEDAGOGICAL SIGNIFICANCE OF THE PROBLEM

There can be no doubt that there is a need, in any progressive educational system, for a better selection and a better organization of instructional content. It has been recognized that a statement of the general aims of instruction is of paramount importance in selecting the content materials. The teachers should use these aims as criteria for judging the worth of materials of instruction. In the organization of many courses of study, syllabi, and textbooks, objectives have been set up, but too often they have not been taken seriously. There has been too wide a gap in

the minds of many teachers between the theoretical selection and explanation of objectives and actual class activity.

Accordingly, in this study, an effort has been made to evaluate a group of instructional practices in terms of a group of selected objectives. The problem of determining the concrete experiences and the instructional practices was not to find out the average performance or what is usually done, but instead, what is done in biology laboratory work by a group of teachers who represent the highest type of instruction in biology as judged by their school superintendents and science supervisors.

The computed total weights for each of the concrete experiences listed in the questionnaire are of value to teachers in the selection of those concrete experiences which are most frequently taught and judged most essential by the teachers cooperating in this study. This weighted list should be of special value to beginning teachers of biology who are confronted with the task of selecting concrete experiences for laboratory study. The methods by which these concrete experiences are most frequently taught may also be of value to these teachers. The best method for presenting these concrete experiences will, however, have to be determined by what eventually proves best for the attainment of the objectives which are set up.

The biology-laboratory curriculum must not be unorganized and miscellaneous in character. It must emphasize freedom with limitations. Soundly planned work on the teacher's part is necessary and desirable. The activities should be so organized that each problem set up by the teacher becomes the problem of the student, which he is eager to solve. The teacher sets the stage for each unit of activity, organizing it so that the student enjoys the work he does.

If the teacher clearly formulates the ultimate and immediate aims of instruction, if the pupils are made aware of the purposes or goals of their courses, and if they share the appropriate views on the objectives to be gained, the student will be "doing what he wishes, and wish what he does."

EVALUATING GENERAL SCIENCE PROJECTS

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In recent years much comment has centered around the encouragement of school projects because of the benefits derived therefrom. Moreover, educational literature abounds in articles relative to values and techniques in project building. There is reason to believe that the teaching of general science furnishes more opportunities to challenge the adolescent mind than some other subjects in a secondary-school curriculum. Therefore, the art of good teaching lies in the ability to take advantage of the enormous amount of creative work afforded in such a subject as general science.

Because of the increasingly widespread interest in junior-high-school science projects, it is the specific purpose of the present report to evaluate in detail certain outgrowths resulting from project making relative to exhibitions. The techniques employed for this type of activity will not be discussed here, as they have already appeared in recent publications. However, it should also be clear that no attempt will be made to determine how lasting these results may be.

The experiment has been conducted in the writer's ninth-grade general science classes of a cosmopolitan high school dur-

ing the academic years, 1935–39. Irvington, typically metropolitan, has a population approximating 67,000. These facts are cited because the size and character of a community have tremendous educational influence on the schools.

Among the findings the following are highly significant:

1. The school and home are brought together in a cooperative enterprise for the better understanding of each other's problems. Notice cooperation is as follows:
   a. The Board of Education furnishes transportation for the exhibits.
   b. Parents assist in building the model [1] and in many instances take the project to school. They hear the child talking over plans and are anxious to compare the finished product with others.
   c. Teachers lend illustrative materials and sometimes offer valuable suggestions.[2]
   d. Pupils help in transportation and in decoration.
   e. Pupils, parents, and faculty attend in considerable numbers at these exhibitions.
2. The school and the home have benefited from publicizing the various exhibits in the leading newspapers and educational magazines. Since the community, through this means, has become more "school-conscious," it is more likely to lend a hand in building up this educational program.
3. Exhibits prove extremely valuable, as they are used from year to year to amply demonstrate some particular scientific phase in a learning-unit. For example, a lighted "Caisson" and the "Making of Fire by Friction" have been displayed many times in the classroom to clinch a certain fundamental principle.
4. From personal observation, such desirable traits as cooperation, leadership, industry, pride, reliability, initiative, and accuracy appeared more pronounced in the individual. Pupils like to be asked to accept a real responsibility but enjoy being commended for good work.
5. As a result of this experimental research, which included an extensive search for well-illustrative incentives and the visitation of numerous educational and scientific exhibitions, pupils and teacher have gained considerable knowledge. This type of investigation is exceedingly valuable because pupils become acquainted with the logical scientific method of thinking.
6. Personal and social problems of the individual are better understood, since the teacher is more likely to come in closer contact with the pupil and parent in this kind of education. It is from the constant follow-up interviews, so necessary for this creative activity,[3] that the pupil and the teacher understand better each other's personal problems. When the parent assists in taking the exhibit to school, frequently the child's welfare will be discussed with the teacher. This is highly important to the teacher, as a full knowledge of the pupil's background may be obtained. Moreover, at this time, the teacher has an excellent opportunity to enlighten the parent as to the understanding of education in an ever-changing world.
7. Some pupils are already making models outside of school hours for other academic subjects. For instance, an excellent piece of work, a miniature reproduction of a mediaeval castle, for

[1] Simmons, Maitland P., "A Father-and-Son Exhibit," *School Activities* 11: 95–96; November, 1939.

[2] Simmons, Maitland P., "Science for Leisure Time," *School Science and Mathematics* 39: 623–627; October, 1939.

[3] Simmons, Maitland P., "Originality of Scientific Models," *Science Education* 22: 195; April, 1938.

ninth-grade history, was made by two boys who had previously won a second award in our school science exhibit for a diorama of Otto von Guericke's famous demonstration of the Magdeburg Hemispheres.[4] It is, of course, true that some will continue well beyond their school career to make projects, simply as a leisure-time activity. Furthermore, recent studies have disclosed that school hobbies often lead to life jobs. It is not uncommon to find a boy or girl following an interest that began in school. An example of this in our school was a pupil who became a newspaper photographer as a result of a special interest in photography. Some people have become famous, not from the life work chosen, but from a hobby that originated in the classroom. Satisfactions derived from working in creative fields as exemplified above have no comparisons. The increasing enthusiasm for hobbies gives proof of this point and is an encouragement especially in the teaching of general science.

8. Socially, the results derived from project making have had far-reaching implications. It is the writer's opinion that from the intimate contact with children, whole-hearted, purposeful activity of this kind appears to be beneficial to the "whole" child, including a positive growth in educational achievements, personality, varied interests, and outlook on life. The school and the home should be the two great constructive agencies affecting the entire child's life. It is commonly agreed that many homes do far too little for their future citizens. Sound preparation for life today is neither accepted nor fulfilled by these homes.

[4] Simmons, Maitland P., "Their First Scientific Project," *Science Education* 22:310–311; November, 1938.

THE VALUE AND METHOD OF EXPERIMENTATION WITH DROSOPHILA MELANOGASTER IN THE TEACHING OF BIOLOGY IN SECONDARY SCHOOLS

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The teacher of biology is often restricted in his work by economic considerations. Although the emphasis in class work is put on simple experimental studies, the extent and usefulness of the latter is usually determined by material, space, and money available. How strange it is then, that economical and instructive experimentation with the fruit-fly *Drosophila melanogaster* has not been used more generally in the classroom. This little fly is not only the ideal tool for the scientist who studies the principles of heredity, but simple experiments with this object can be introduced in the high-school teaching of heredity without any difficulties. Heredity has become an important field in teaching of biology in secondary schools because its advances and applications in the last 30 years have been so manifold that every student should get at least an understanding of its principles. The unit on heredity can doubtless be made an extremely interesting one, particularly if demonstrated with adequate, instructive and interesting experiments. The writer has had some experience in introducing experimentation with fruit-flies into several high-school laboratories and has been well rewarded by the interest and enthusiasm of the students who were given the opportunity of doing independent work. The purpose of this article is to give some sug-

gestions about the laboratory work with the fruit-fly as adapted for use in the high-school, the technique of raising and breeding the flies, of recording the results, and some examples of informative experiments.

MATERIAL AND METHODS

The fruit-fly represents ideal material for experiments on heredity because its life-cycle is extremely short and its fecundity very high. A female lays an average of 200–300 eggs, the larvae hatch after 1 day, pupate after 4 more days and the young flies hatch 10 days after egg-laying (at 25° C.), becoming fertile within a day.

The flies are bred easily in ordinary milk-bottles or large vials which contain a medium of agar-agar, molasses and corn meal on which a suspension of yeast is sprayed. The exact formula for the food is:

100 g. corn meal
95 c.c. sulphur free molasses
8 g. agar-agar
700 c.c. water

The agar is first dissolved in 500 c.c. of boiling water. The molasses is added and the mixture is again brought to the boiling-point. Finally the corn meal which has been soaking in the remaining 200 c.c. of water is added. After the whole mixture is brought again to the boiling-point it is poured while warm into the bottles (if possible, previously sterilized). The medium should be approximately 1 in. high. Two sheets of tissue-paper or strips of paper-towel are put into the medium in order to soak up excess moisture. The bottles should be closed immediately with a stopper consisting of cotton wrapped in cheese-cloth. After the medium has cooled a suspension of Fleischmann's yeast (1 c.c. to one glass of water) is sprayed on the food. The cultures are then ready for use. If not needed immediately, they can be stored in an ice-box for approximately 4–5 days. (Fig. 1.)

The different stocks of flies are kept in mass-cultures which have to be transferred

FIG. 1. A culture-bottle for Drosophila and a simple etherizing jar.

every 2–3 weeks to new bottles. Only few stocks are needed for school experiments, the important ones are:

1 Normal ("Florida" or "Oregon," has red eyes, gray body-color and long wings.)
2 vg (—vestigial, wings reduced to rudiments, factor located in the II chromosome.)
3 w (—white, eye-color, factor located in the I chromosome.)
4 Cy (—Curly, wings curled upwards, factor located in the II chromosome.)
5 e (—ebony, body-color, located in the III chromosome.)
6 b vg (b—black, body-color, factor located in the II chromosome.)

These stocks can be obtained from several places. In the East: Dept. of Genetics, Carnegie Institution of Washington, Cold Spring Harbor, New York. In the West: Dept. of Biology, California Institute of Technology, Pasadena, Calif.

In order to transfer the flies to new bottles, the old bottle is shaken, thereby dropping the flies to the bottom, then the stoppers of the new and old bottle are quickly removed, the old bottle inverted over the other and the flies shaken into the new bottle. From time to time the flies should be checked, when transferred. For checking the stocks and recording the

flies of an experiment etherization of the flies is necessary. A ¼ pint cream-bottle is best suited for an etherizing-jar. It is fitted with a cork-stopper with a plug of gauze nailed at the lower side. (Fig. 1.) Several drops of ether placed on this plug suffice to etherize many flies very quickly. The flies are shaken into the etherizing-jar and kept in it for about 30 seconds more than it takes them to stop moving. If they are overetherized they will turn their wings straight up. Little experience is needed to get the correct time of etherization. They are then placed on a white plate or a piece of paper and can be examined with a dissecting microscope; however a simple magnifying glass is sufficient for the observation of all the mutations used in the experiments described below.

Male and female flies can easily be distinguished. The males are slightly smaller than the females and have a round, solidly dark abdomen, while the abdomen of the female is pointed and has dark bands on it. (Fig. 2.) A forceps or camels-hair-

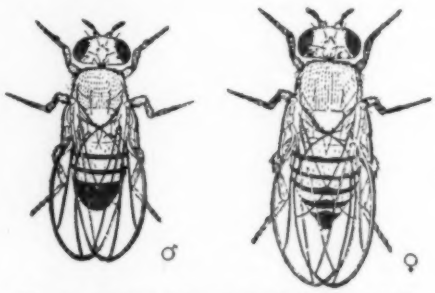

FIG. 2. Male and female fruit fly, *Drosophila melanogaster*. (After Morgan, from Sinnot and Dunn, Principles of Genetics, McGraw-Hill Book Co.)

brush is the only tool needed for examinations. Should the flies start to wake up during the examination, the top of a petri-dish, to the inside of which a patch of gauze has been fastened and soaked with ether, is placed over the flies for several minutes to give them an additional etherization.

For individual crosses one or two females and two or three males are mated in each bottle. The parental flies should be removed after 5–8 days in order to avoid overcrowding. If two different mutants are crossed, the female—of course—has to be a virgin when she is crossed with the other mutant. The simplest way to obtain unfertilized females is to remove all flies from a culture in which flies are just hatching; this is best done early in the morning. All the females which hatch in the next 6 hours can be regarded as unfertilized and can be used for crosses. Females which are only 1–6 hours old are less pigmented than old females and often have their wings still folded; they may safely be considered to be still unfertilized.

The offspring of a cross should be examined and recorded not earlier than 12 days and not later than 17 days after the mating of the parents, preferably after 15 days. (These figures are for 25° C. If the cultures are kept at room-temperature, 2–3 days more should be allowed.) The individual crosses should be numbered and dated. It is wise to make up at least 6–10 identical crosses at the same time, because not all cultures will be successful. An example for a Drosophila culture record is given below:

Parents: Culture No.....

.....from.....started.....

.....from.....parents removed.....

CLASSES

Dates counted									
	♀	♂	♀	♂	♀	♂	♀	♂	
.....	..	..	..	..	..	..	..	..	.....
.....	..	..	..	..	..	..	..	..	.....
.....	..	..	..	..	..	..	..	..	.....
.....	..	..	..	..	..	..	..	..	.....
Totals:									

Remarks: .....

EXPERIMENTS

Experiments # 1–3 are best suited for an introductory course in biology; experiments # 4–6 are for more advanced students.

The genetic formula is written in the form of a fraction with the numerator representing the factors located in one chromosome and the denominator the corresponding factors in the other chromosome of the pair. The normal allele to a factor is designated by a sign.

1. Dominance. The factor Cy (Curly) is a dominant factor which is lethal in homozygous $\left(\frac{Cy}{Cy}\right)$ condition.

P (—Parents): $\frac{Cy}{+} \times \frac{+}{+}$ (—heterozygous Cy-fly, as always present in Cy-stock, crossed with normal fly).

F_1 (—first generation): $\frac{Cy}{+}$ (—Curly flies) and $\frac{+}{+}$ (—normal flies) in a ratio of 1:1.

2. Recessive factors. vg (—vestigial) is crossed with normal fly. The genetic formula would be $\frac{vg}{vg} \times \frac{+}{+}$. F_1: all flies look normal $\left(\frac{+}{vg}\right)$.

3. Monohybrid Mendelian ratio 3:1. The F_1-flies from experiment # 2 are inbred: $\frac{vg}{+} \times \frac{vg}{+}$. In the F_2 (—second generation) a segregation of 3:1 can be observed, 75% normal flies and 25% vestigial flies $\left(\frac{vg}{vg}; \frac{vg}{+}; \frac{vg}{+}; \frac{+}{+}\right)$. In order to demonstrate the genetic difference of the normal appearing flies of the F_2 these flies can be crossed to vg-flies. Some of them will only show normal offspring $\left(\frac{+}{+} \times \frac{vg}{vg} \longrightarrow \frac{+}{vg}\right)$, others will give vg-offspring and normal offspring $\left(\frac{+}{vg} \times \frac{vg}{vg} \longrightarrow 50\% \frac{+}{vg}; 50\% \frac{vg}{vg}\right)$.

4. Dihybrid Mendelian ratio 9:3:3:1. Cross between e (—ebony, factor located in the third chromosome) and vg (—vestigial, factor located in the second chromosome).

P: $\frac{+}{+}\frac{e}{e} \times \frac{vg}{vg}\frac{+}{+}$. F_1: $\frac{+}{e}\frac{vg}{+}$ looks normal. Brother-sister mating of this F_1: $\frac{+}{e}\frac{vg}{+} \times \frac{+}{e}\frac{vg}{+}$. The segregation in F_2 is: 9/16 normal, 3/16 ebony, 3/16 vestigial and 1/16 vestigial ebony.

5. Sex-linked inheritance. The recessive w (—white eyes) is located in the first, the sex- or X-chromosome of Drosophila. Males receive only one X-chromosome, females two. Therefore the offspring from the cross between white eye female and normal male ($♀ \frac{w}{w} \times ♂ +$) will be: all males white, because the males get their X-chromosome from the white mother; all females, however, will look normal $\left(\frac{w}{+}\right)$. The reciprocal cross gives a different result:

Parents: $♀\frac{+}{+} \times ♂ w$.

F_1: all flies look normal ($♀♀ \frac{+}{w}$; $♂♂ +$).

6. Linkage and crossing-over. The factors b (—black body-color) and vg are located in the same chromosomes (II). These factors are called linked and usually no independent assortment will take place between b and vg in the F_1 of a back-cross between $\frac{b\ vg}{+\ +}$ and $\frac{b\ vg}{b\ vg}$. If the mother however is the hybrid this linkage will be broken in a certain percentage by so called crossing-over. No crossing-over takes place in males. This is demonstrated in the following crosses:

P: ♀ or ♂ $\frac{b\ vg}{b\ vg} \times$ ♀ or ♂ $\frac{+\ +}{+\ +}$.

F_1: $\frac{b\ vg}{+\ +}$, all flies look normal.

I. *Linkage:*

P_1: ♀$\frac{b\ vg}{b\ vg}$ (from stock) × ♂$\frac{b\ vg}{+\ +}$ (from F_2 of # 6).

F_2: 50% $\frac{b\ vg}{b\ vg}$ (black vestigial) and

50% $\frac{b\ vg}{+\ +}$ (look normal).

II. *Crossing-over:*

P_1: ♀ $\frac{b\ vg}{+\ +}$ (from F_1 of # 6) × ♂$\frac{b\ vg}{b\ vg}$ (from stock).

F_2: 41% b vg-flies $\left(\frac{b\ vg}{b\ vg}\right)$,

41% normal looking flies $\left(\frac{b\ vg}{+\ +}\right)$,

Cross-over flies:

9% flies $\left(\frac{b\ +}{b\ vg}\right)$,

9% vg-flies $\left(\frac{+\ vg}{b\ vg}\right)$.

The percentage of cross-over flies to the total number of flies is 18 per cent; this represents the relative distance between the two factors in the second chromosome.[1]

[1] See Sharp, *Introduction to Cytology*. McGraw-Hill Book Co., for linkage map.

CONCLUSIONS

The results obtained from the foregoing experiments will naturally show only an approach towards the ideal ratio. In order to obtain figures close to the expected ratio the results of all students should be added up.

The total time required for an experiment in which the offspring of only one generation is observed (# 1 and 2) is 2–3 weeks, 4 weeks are required for a two-generation experiment.

In addition to these crosses a demonstration of different mutations of Drosophila is of instructive value, because several interesting facts can be shown easily with this material. (1) All parts of the body can be affected by mutations (eye-color: normal, white, brown, sepia, peach; shape of the eye: normal, eyeless, kidney, Bar; body-color: normal, black, yellow; wings: normal, miniature, Curly, vestigial, Dicheate, dumpy, cut, rudimentary, balloon; legs: normal, dacks, thick; body-size: normal, giant, dwarf; bristles: normal, Dicheate hairy, shaven). (2) The manifestation of a factor can be variable (abnormal abdomen, eyeless). (3) Similar characters can be produced by different genes (dark body-color: black and ebony, bright red; eye-color: scarlet, vermillion and cinnabar; curled wings: Curly and curled).

By working with this material the student will not only learn the principles of heredity. He is also given the opportunity of learning how to handle living material, he can observe and examine the different developmental stages, and he can note the influence of temperature on the time of development.

All these suggestions will be expanded by the teacher himself after he has gained some experience in the experimentation with this simple and instructive material, the fruit-fly Drosophila melanogaster.

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90-TON "CANNON" SMASHES TINY ATOMS *

Ohio State University's new 90-ton atom-smasher will be ready for operation early in January, 1940, according to Dr. M. L. Pool of the Ohio State University Physics Department who is supervising construction of the giant scientific machine. At that time this new device for exploring the mysterious realm of radio-active substances and elements will begin its atom-smashing barrage which will transform one element into another and accomplish quickly and easily the transmutation of metals, a feat which the ancient alchemists vainly strove for centuries to achieve.

Scientists hope by means of this machine to create cheaply radio-active substances which will be valuable in the treatment of certain diseases for which rare and expensive radium is now used.

The atom-smasher is being built as a WPA project and mechanics and radio electricians on the payroll of the Work Projects Administration are assembling and installing the huge device. The WPA workers have nicknamed the machine "Big Bertha" and its atom-smashing barrage will, in a manner of speaking, simulate the fierce fire of the "Big Bertha" guns used in wartime. The atom-smasher's barrage, however, will be for the advancement instead of the destruction of mankind.

* Article prepared by Division of Information, Work Projects Administration, and approved by Dr. M. L. Pool.

Dr. Alpheus W. Smith is chairman of the Physics Department and experiments will be conducted under this department of the university.

If the atomic energy in a lump of sugar could be released and harnessed it would be sufficient to pull a long freight train across the continent five times, scientists point out. Our oil and coal reserves could be forgotten. Atomic motors would take the place of windwills, water-wheels, steam, gasoline and other energy-producers.

By exploring the inner recesses of an atom, Dr. Pool and his associates hope to contribute to the recent discoveries which have brought scientists closer to understanding the basic mystery of matter itself.

With the cooperation of the Departments of Medical Research, Electrical Engineering, Chemistry, Biology, Botany and Veterinary Medicine a broad field of investigation will be made possible in the future, according to Dr. Pool.

Total cost of the atom-smasher will be about $46,000. WPA is providing $20,000 for the labor to assemble and install this powerful new weapon of science while the university is providing $26,000, mostly for the cost of the materials. A substantial portion of the university's share of the cost was contributed by Dr. Julius F. Stone, of Columbus, Chairman emeritus of the university board of trustees. This was the first gift made to Ohio State University through the newly-organized development fund.

Like all other WPA projects, this project was undertaken by the WPA to provide jobs and wages for unemployed workers. About a dozen machinists, radio electricians, tool and die makers and pattern makers have been given employment on the project.

Atom-smashing is the most spectacular, most exciting development in modern physics and America leads the world in the smashing.

There are 37 atom-smashing machines in operation or under construction in the world. Of these, only eight are outside of the United States.

The eight are located in Zurich, Moscow, Copenhagen, Paris, London, Liverpool and Tokio which has two.

There are two types of atom-smashers—cyclotrons such as Ohio State University has, and electro-static machines. There are 18 other cyclotrons besides the one at Ohio State. They are located at Princeton University, University of California (2), University of Rochester, Columbia University, Cornell University, University of Pittsburgh, University of Michigan, Harvard University, Massachusetts Institute of Technology, Bartol Research Foundation of the Franklin Institute at Philadelphia, Yale University, University of Indiana, University of Illinois, University of Chicago, Purdue University, University of Washington, Washington University at St. Louis.

The electro-static atom-smashers are located at the Massachusetts Institute of Technology, Huntington Hospital at Boston, Westinghouse Research Laboratories, Department of Terrestrial Magnetism of Carnegie Institute, the University of Wisconsin (2), University of Minnesota, California Institute of Technology and Notre Dame University.

At the University of California, the university hospital is already using radio-active sodium transmuted from ordinary sodium for the study of cancer and other medical problems in the place of the costly radium. The new substance has many properties that are most advantageous for medical and biological experimentation.

The creation of new substances in large quantities was a dream of the physicists just a short time ago. Now it is an accomplished fact. A cyclotron of this type is capable of creating annually thousands of dollars worth of radio-active materials which are obtainable by no other means. A cyclotron bombarding ordinary sodium

for one day creates enough radio-active sodium to equal 10,000 grams of radium.

Harnessing of the atomic energy for commercial purposes is the next goal. Scientists believe they have a long way to go to reach this goal and that is why it is important that as many of them as possible be provided with atom-smashers.

However, discoveries up to date have fired the imaginations of physicists and encouraged them to an incalculable degree.

First transmutation was achieved in 1919 by the English scientist, Lord Rutherford, who used the alpha particles from radium to bombard other substances.

In 1933, Professor Ernest O. Lawrence of the University of California, confounded the critics who raised their eyebrows over his experiments by inventing and successfully operating the world's first cyclotron.

Today, nearly all of the 92 elements have been transmuted.

With the aid of atom-smashers, scientists have created 232 new radio-active atoms in addition to the 45 natural radio-active substances previously known.

Of these 232 radio-active atoms, 147 emit electrons and 65 emit positrons. The positron has the same mass but the opposite charge to that of the well-known electron. Chemistry up to the present time deals with only 281 atoms distributed among the 92 elements.

An important development in this nuclear field came last January when a German scientist announced the splitting of uranium into other elements which are very much lighter in weight. This was quickly confirmed by various scientists in America. In ordinary transmutation accomplished previously, the scientists had succeeded only in adding to or subtracting a few units of mass from the nucleus of an atom. The new experiments split the uranium atom completely asunder, thereby creating two atoms of elements with masses approximately half the original mass.

An atom is a solar system in miniature with the nucleus being the sun. This nucleus is made up of protons and neutrons. Whirling around this nucleus in orbits in much the same manner, but at a much greater relative distance, as the earth and other planets whirl around the sun are electrons. These electrons have a negative charge and are about one-2,000th as heavy as the above mentioned protons and neutrons. This shows that the main business of the atom is in the nucleus. These two particles are fundamental building blocks, each having the same mass. The proton has a positive charge of one unit. The neutron has no charge.

There are about 1,000 billion billion atoms in an ordinary grain of sand.

For bullets for their cyclotron, the Ohio State University physicists will use deuterons, protons and alpha particles. These they will fire at the atoms of the substances to be transmuted at the speed of a million miles per minute.

A deuteron is the nucleus of the heavy hydrogen atom (from a "heavy water" molecule). The nucleus of the ordinary hydrogen atom consists of only one proton while the nucleus of the heavy hydrogen atom, called the deuteron, consists of one proton and one neutron.

As the initial electrical impulse of 50,000 volts is applied to the semi-circular D-shaped electrodes of the cyclotron, the deuterons, protons or alpha particles (charged particles) leap from electrode to electrode picking up 50,000 volts. The magnetic field supplied by the 90-ton magnet causes these particles to swing around in a spiral curve and thus to return to the region between the plates. In this manner these particles can pick up another 50,000 volts. After 200 such crossings of the gap between the electrodes, the deuteron bullet will have picked up a total of 10,000,000 volts.

The atoms of the substance to be smashed are placed on a target made of copper or some other metal at which the current of

deuterons, protons or alpha particles is directed.

The electrical impulse will come from a short 50 kilowatt radio transmitter which has a frequency of 10 megograms or a wave length of 30 meters. Professor W. L. Everitt of the Department of Electrical Engineering is in charge of this phase of the work.

Special precautions will be taken to protect the operators from the neutrons created by this 10,000,000 volt, million-mile-per-minute bombardment. Heavy metals such as lead are effective in stopping x-rays but have been found to be almost useless in stopping these artificially-created neutrons. To protect themselves from these penetrating neutrons, the operators and observers will stand behind huge tanks of water two feet thick and will also carry electroscopes so that they can determine at all times just how much radiation they have been subjected to. When they reach the safety limit, they will leave the machine until the next day. Under these conditions there will be no harmful effects from the use of the machine.

To shield the radio transmitter so that it will not cause interference to receiving sets in the neighborhood, the WPA workmen will install 1,000 pounds of copper sheeting.

Dr. Pool took his B.A. degree at the University of Chicago in 1924 and his Ph.D. degree there in 1927. Coming to the Ohio State University, he conducted atomic nuclear research with high voltage transformers. Awarded the Elizabeth Clayton Howald Scholarship, he studied cyclotron operation and theory at the University of Michigan in 1936–37. The Ohio State University cyclotron was begun in January 1938.

Dr. Pool's colleagues in the cyclotron experimentation are Dr. Kenneth More and Dr. E. R. Gaerttner.

Abstracts

GENERAL

EGENTON, DANIEL P. "Principles to be Observed by Teachers." *High School Journal* 28: 108–113; March, 1939.

Although this article does not apply directly to science teaching it should offer food for thought to teachers in any field. Many of us who teach on the college level should, perhaps, take to heart the description of the educational theorist who does not apply his theory. The article gives an excellent, brief and clear summary of principles which should be observed by a teacher. These generalizations are grouped under sociological principles and psychological principles. Considered as a whole these embody a philosophy of education expressed in a terminology singularly free from the technical expressions which so often serve to confuse the reader who is not familiar with the specialized vocabulary of the philosopher and the specialist in educational theory.

—O. E. Underhill

CONKLIN, EDWIN G. "Education for Democracy." *The Journal of the National Education Association* 26: 165–168; September, 1939.

"It seems incredible that all the marvelous complexities of an adult person should have issued from so simple a beginning in the egg. If we did not know that it is true it would be incredible that the greatest men that ever lived —Socrates, Plato, Aristotle, Newton, Darwin, Pasteur, Shakespeare, Goethe, Beethoven—were once babies, embryos, and germ cells, and yet no one can deny this. This ever present miracle of development is the most wonderful thing in the world.

"Education is the attempt to direct development into beneficial channels by means of proper stimuli. All the teacher can do is to stimulate the pupil and by the choice of appropriate stimuli seek to bring forth the desired response. Democracy is not merely a form of government, but a way of life, a set of social habits, a code of ethics."

—C.M.P.

LORGE, IRVING. "Psychological Bases for Adult Learning." *Teachers College Record* 41: 4–12, October, 1939.

Mental ability and ability to learn do not decline in the same ratio as do motor and sensory capacities. Mental speed tests give a wrong index of the mental abilities of adults.

In the acquisition of information, the development of appreciation, the habituation of skills, the establishment of attitudes, reward works, and works well. In setting any learning situation, the teacher should base method upon reward, and should avoid punishment. The basis of learning is the individual's ability, capacity, and drives.

—C.M.P.

JACKSON, DUGALD C. "Engineering's Part in the Development of Civilization." *Science* 89: 231–237; March 17, 1939.

This article deals with the social significance, influence, and implications of engineering on society. In many ways, engineering made civilization possible. Much better usage can be made of the findings and knowledge of present engineering than is being done now, but engineers are not responsible, as individuals or as groups, for many of the misuses of engineering principles and applications.

—C.M.P.

ANONYMOUS. "Best Cities Distinguished by Dentists, not Clergymen." *Science News Letter* 35: 284; May 6, 1939.

This summarizes a study by Dr. Edward L. Thorndike on the G (Goodness) rating of cities of over 30,000 population in the United States. Good dentists, not clergymen, are characteristic of the best cities. Good cities have an abundance of artists, engineers, musicians, nurses, and teachers. They have few lawyers, actors, veterinarians, and domestic servants. The G listing of various cities is included.

—C.M.P.

LORGE, IRVING. "Looking 'Em Over: Dissertation Analysis." *The Advanced School Digest* 4: 6–7; December, 1938, January, 1939.

The author presents an outline for analyzing a dissertation. The major points are: (1) aim or purpose must be specified by a question or series of questions, (2) each question must be analyzed on the basis of the nature of the assumptions or premises, or both, (3) the assumptions or premises must be justified on the basis of some criterion for knowing, (4) the previous evidence, where available, should be utilized, (5) restatement of the questions still unanswered for which evidence must be secured, (6) selection of methods for getting evidence, (7) justification of the methods, (8) collecting the evidence, (9) treatment of the evidence, (10) conclusions, and (11) interpretations.

—C.M.P.

ALLEN, ROBERT I. "Science Versus Unemployment." *Science* 89: 474–479; May 26, 1939.

Discoveries and inventions have stimulated and promoted employment rather than having caused

unemployment. The author cites much statistical data from various industries to enforce his contentions. However, he admits that if labor-saving devices were all eliminated there would be no unemployment. For example, if the cotton-gin were eliminated and cotton production maintained at its present rate, it would take 37,000,000 people (one-fourth of our population) working eight hours a day for 300 days to separate by hand the seed from the cotton plant. Yes, there is one way of solving unemployment—abolish labor-saving devices!

—C.M.P.

LORGE, IRVING. "Integrity in Research." *The Advanced School Digest* 4: 5–8; April, 1938.

This article discusses integrity in reporting educational research studies and attempts to answer such questions as: "Must my data be checked by somebody?" "Must I indicate all the assumptions underlying the formulae I use?" "Must I indicate why I am omitting these data that I have collected?" "Is it my business to point out that some of the data are contrary to the general conclusions?" "In this experiment I made a mistake in timing of three seconds; should I report it anyway?"

—C.M.P.

WHEELER, RAYMOND H. "Social Behavior Patterns and Climate." *The Social Frontier* 5: 231–237; May, 1939.

Cultural epochs in widely separated areas have come and gone on tides of climatic change. During long periods of drought vast pastoral regions became uninhabitable, migration started, and cities were abandoned. At other times, the onset of a warm-wet climate has helped to destroy certain cultures through disease and uncontrollably rank vegetation, as in the case of the Mayans and Angkors. The most successful civilizations have evolved in temperate zones where climatic changes are frequent but not too extreme.

Civilization and climate are closely correlated. Significant events have been associated with climatic changes, not only during the modern age, but also in prehistoric and the Christian Era. Indications are that a serious World War will not now develop, unless it does so very rapidly, (written in May) and indications are more indicative of a series of civil wars.

—C.M.P.

GREGORY, SIR RICHARD. "Science, Religion, and Social Ethics." *Science* 89: 165–166; February 24, 1939.

Though science is unable to provide any positive evidence for survival of personality after death, it must acknowledge that belief in such survival is a powerful ethical factor in human development. The applications of science have many ethical and social consequences. Science can only continue to render its fullest service to the community as the relations between the general scientific worker and the general citizen are harmonized, and the methods of science are widely understood.

—C.M.P.

DOUGHTON, ISAAC. "Man's Place in Nature." *The Educational Forum* 3: 302–310; March, 1939.

The sublime picture of man, pictured by David as being made "but little lower than God," remained as the western ideal of man until the devastating work of modern science within the past four centuries. The work of Copernicus and Darwin primarily were responsible for this picture of the degradation of man.

In the past decade or so, has come a revulsion from these mechanistic and bestial views of man's place in nature. This has arisen from three definite criticisms of the simple straight-line theory of the early Darwinians: (1) Personality does not seem to find a due place in the cruder mechanical theory, (2) the theory of emergent evolution, and (3) failure of the earlier Darwinian theory to recognize the progressive compounding of human culture by and through itself.

There are also the following distinctly human powers (in addition to the opposable thumb, the rods and cones of the retina that make color vision possible, the upright posture of the body, etc.): (1) the power of conceptual or ideational thought, (2) the power of speech, (3) the power of memory, (4) the power of imagination, (5) the power of reasoning, (6) the power of rich emotions, (7) the power of vicarious experiencing, and (8) the power of discriminating "right" from "wrong", commonly called "conscience."

—C.M.P.

POPENOE, PAUL. "Your Inferiority Complex." *Scientific American* 160: 288–290; May, 1939.

Few of us attain that perfect balance between the two extremes of actual inferiority and self-importance that constitutes emotional maturity. The inferiority complex is probably commoner, and one hears of it much more frequently. Usually the victim of an inferiority complex attempts to escape from his discomfort by one or more of the following compensations: (1) bluffing, (2) posing, (3) passing it on to others, (4) reforming others, (5) rationalization, (6) humility, (7) throwing up a cloud of dust, and (8) hitching his wagon to a star. You can help overcome your inferiority complex by recognizing your disabilities and overcoming your disabilities if possible.

—C.M.P.

DAVIS, EMILY C. "To Swing Off to War." *Science News Letter* 36: 42–43; July 15, 1939.

Emotional desires influencing many people are: (1) to be popular, (2) to be with the crowd, (3) to get as much as possible for as little effort as possible (efficiency), (4) to get as much as

possible for as little money as possible (economy), (5) luxury, (6) sex, (7) appetite, and (8) curiosity. The fears are: (1) fear of being poor, (2) fear of being ugly, (3) fear of being neglected, or left out of the crowd, and (4) fear of social disapproval. Seven common devices for appealing to these almost sure-fire fears and desires are: (1) name calling, (2) using glittering generalities, (3) testimonials, (4) the plain folks line, (5) card stacking, (6) appeal to jump on the band wagon, and (7) suggesting by transfer that you can be like some admired person.

—C.M.P.

WIGHAM, J. T. "War, Famine, and Pestilence." *Science Digest* 5:69–72; June, 1939.

For the first time in human history, in the World War of 1914 to 1918, disease did not claim more victims than did weapons. In the Boer War more men died of typhoid than of battle injuries. During the Crusades, Frederick Barbarossa lost the whole of his army after the capture of Rome in 1167, and during the First Crusade at least 100,000 men died from disease. During the Thirty Years War, the population of Central Europe was reduced from 30,000,000 to less than 13,000,000 and the loss from injuries in battles was not over 500,000. In the Civil War, 182,000 men were killed and 365,586 died of disease. In Justinian's time, a plague lasted fifty-two years, and during the three months at its height 5,000 to 10,000 died every day in Constantinople. Many cities of the East were left vacant.

The Black Death of the fourteenth century caused 25,000,000 deaths, a quarter of the population of Europe. But the influenza epidemic of 1918–1919 is believed to have been as great. It is estimated that influenza then caused 20,000,000 to 30,000,000 deaths.

—C.M.P.

LEVINSON, HORACE C. "Science Examines Games of Chance." *Science Digest* 5:15–19; June, 1939.

This is a condensation from the book *Your Chance to Win* by the same author. Fallacious ideas relating to the laws of chance are presented, as well as what constitutes fair odds in betting.

—C.M.P.

SCIENCE

ANONYMOUS "Miracle of New Color Movies." *Popular Mechanics Magazine* 71:333–344, 128A–129A; March, 1939.

A good presentation of the details of film and camera by means of which colored movies are made. Diagrams are unusually enlightening. Examples of recent familiar technicolor films are given to illustrate the problems involved. The history of the development of color motion picture photography is also brought out.

—O. E. Underhill

ANONYMOUS "Magic Tubes of Daylight." *Popular Mechanics Magazine* 71:641–643, 146A–147A; May, 1939.

New lamps in which ultra-violet radiation from a mercury arc excites fluorescent powders, producing almost any color including white. Such lamps are much more efficient than incandescent lamps for furnishing color illumination. Each lamp consumes about 10 watts per foot of length, the longest being three feet. Details of construction, advantages and disadvantages, and future possibilities are given.

—O. E. Underhill

MATHER, KIRTLEY F. "Earth Structure and Earth Origin." *Science* 89:65–70; January 27, 1939.

Whether the earth and other planets were formed mainly by the slow agglomeration of small cold bodies (planetesimal hypothesis) or whether they were all once liquid and have picked up much less matter in latter times (tidal hypothesis) is of primary concern to the geologist. Theories of the processes of mountain formation, the origin of igneous rock, the mechanisms of volcanic eruptions, or the dynamics of isostasy, are all related to which theory is accepted.

After citing geological investigations into the nature of the structure of the earth, Dr. Mather states in conclusion that the concept of earth structure based on recent geophysical and seismological research is not nearly so unfavorable to the acceptance of the planetesimal theory of earth origin as many geologists have supposed.

—C.M.P.

BOWEN, NORMAN L. "Geology and Chemistry." *Science* 89:137–139; February 17, 1939.

Chemistry has and is throwing much light on the nature of many geological processes—rock, weathering, ore formation, sedimentation, and so on. A geologist needs a sound background of physics and chemistry.

—C.M.P.

MCMILLION, OVID MILLER. "Reindeer Trek." *The Journal of Geography* 38:133–141; April, 1939.

This is an account of one of the greatest animal treks in all history. The Canadian government contracted with the Lomen Reindeer Corporation for the delivery of 3,000 deer at Kittygozuit in return for $195,000. It was estimated it would take two years to drive the deer from Alaska. The expedition started with 3,440 deer from Kotzebue Sound, in Alaska, in December, 1929. After traveling about 2,500 miles and consuming more than five years, 2,370 animals

were delivered on March 6, 1935. In 1937 the herd had increased to 4,000. This part of Canada can support half a million deer, assuring a steady meat diet and a source of clothing to the natives.
—C.M.P.

NIGRELLI, ROSS F. "Fish Out of Water." *Science Digest* 6: 55–59; June, 1939.

This is condensed from the Bulletin of the New York Zoological Society. Among the fish described are lung fish, some species of which have been kept alive four years when out of water; climbing perch that climb trees; fish that attack men walking beside the pools at low tide; mud-skippers, and so on. —C.M.P.

LANE, CECIL T. "The Strange Behavior of Helium." *Science Digest* 5: 8–12; May, 1939.

This article is condensed from The Yale Scientific Magazine. Liquid helium will not freeze, even at absolute zero. It is the only substance that will not solidify. Near absolute zero, helium acts as if it existed in two modifications, each form having different properties. One form exhibits the peculiar and as yet unexplainable "Transport Phenomenon" — that of flowing counter to gravity.
—C.M.P.

WOLF, WILLIAM. "Animals Bring Us Diseases." *Scientific American* 160: 282–284; May, 1939.

Pets, domesticated and wild animals are hosts to parasites and carry bacilli causing serious human ailments and often death. Among these are anthrax from sheep and cattle, trichinosis from hogs, glanders from horses and mules, undulant fever and tuberculosis from cattle, rabies from dogs and other animals, parrot fever from parrots and certain other birds, bubonic plague and typhus fever from rats, tularemia from rabbits, and so on.
—C.M.P.

EARLE, OLIVE. "Rugged Individualists of the Plant World." *Natural History* 43: 216–219; April, 1939.

Illustrations and discussions of unusual plants constitute this article. Plants described are: Venus's fly-trap, self-plotting plant, peanut, the chocolate tree, the sensitive plant, pineapple, the hurricane plant, and mangrove.
—C.M.P.

MOHR, CHARLES E. "I Explore Caves." *Natural History* 43: 190–204; April, 1939.

This is a very interesting article on life found in caves, supplemented by numerous and excellent photographs.
—C.M.P.

FELSING, W. A. "Chemical Resources of the Southwest." *Journal of Chemical Education* 16: 212–214; May, 1939.

Chemical resources of Arkansas, Louisiana, New Mexico, Texas, and Oklahoma, include petroleum, natural gas, potash, sodium sulfate, salt, the alkali industry, sulphur and sulphuric acid, ceramic materials, cotton-oil industries, bauxite, lead and zinc, mercury, graphite, soy beans, naval stores, paper, copper, and silver.
—C.M.P.

PETERSON, J. MERRIAM. "History of the Naval Stores Industry in America." Part I, *Journal of Chemical Education* 16: 203–212; May, 1939.

The naval stores industry is one of the oldest in America, dating back to 1606. In 1937–1938 the United States had 53 per cent of the world's naval stores production. This was valued at more than twenty-seven million dollars. The leading naval store states in 1937–1938 were Georgia with 57 per cent, Florida, 26 per cent, and Alabama, 9 per cent. —C.M.P.

ANONYMOUS. "Metal of the Future Has Extraordinary Stiffness." *Science News Letter* 35: 340–341; June 3, 1939.

Beryllium, now very scare, would revolutionize industry and aviation if ever found in large quantities. Beryllium, lighter than aluminum, makes alloys that are very light, very tough, extremely high tensile strength, and are excellent conductors of electricity.
—C.M.P.

DARLING, F. FRASER. "The Puzzle of Antlers." *Discovery* 2: 287–292; June, 1939.

The outstanding fact about the antlers of deer, the only family of mammals that grow them, is that they are not permanent structures. Antlers are a modification of hair growth, but are of the same substance as bone, a stable compound of calcium and phosphorus. Biologically, antlers are expensive to produce, and their value is actually negative. The article also traces the development and growth of antlers.
—C.M.P.

BIRD, ROLAND T. "Thunder in His Footsteps." *Natural History* 43: 254–261, 302; May, 1939.

This is the intensely interesting story of the author's discovery of the first footprints ever found of one of the most stupendous creatures ever to walk upon the surface of the earth—a giant sauropod dinosaur. It weighed from twenty-five to thirty tons, was fifteen feet high, and more than sixty feet long. The footprints, found near Glen Rose, Texas, were made in the Texas mud 120 million years ago.
—C.M.P.

BIRNBAUM, MARTIN. "In an African Volcano." *Natural History* 44: 14–19; June, 1939.

This is the story of a thrilling climb through hail and storm to a monstrous cauldron of fire and molten rock just below the equator. The author describes Nyamuragira as far more impressive than Vesuvius, Etna, Stromboli, Mount Batoe, on Bali, or the Hawaiian volcanoes.
—C.M.P.

BOGERT, C. M. "Reptiles Under the Sun." *Natural History* 44: 24–37; June, 1939.

Recent investigations show that most desert reptiles, long regarded as the world's most hardened sun-baskers, succumb in a matter of minutes to temperatures which man finds only moderately uncomfortable. These include the Desert Diamonback Rattler, Desert Iguana, Red Racer, Granite Scaly Lizard, etc. These animals beat the heat by color change, food storage, speed, rock recluse, night eyes, earth tunneling, temperature "eye", sand diver, and canyon dwelling. An altitude graph, showing maximum heights at which various animals are found, is included.

—C.M.P.

RUSSELL, HENRY NORRIS. "What Keeps the Stars Shining?" *Scientific American* 160: 368–369; June, 1939.

The source of the heat of stars has long been an intriguing question for the scientists, and many theories have been advanced, only to be cast aside later. The sun is sending out 4,200,000 tons of heat into space every second, but even at this rate the sun will last 15,000 billion years. The source of the sun's heat, as well as that of the stars, is now believed to be due to reactions between charged atomic nuclei. This results in a net diminution of the total mass, and the liberation of energy.

—C.M.P.

NEWMAN, BARCLAY MOON. "Sulfanilamide and Sulfapyridine." *Scientific American* 160: 362–363; June, 1939.

Great discoveries in chemotherapy are rare and today there are only a few great specifics such as quinine for malaria and the arsenical compound for syphilis. Sulfanilamide and sulfapyridine, two newly developed drugs, offer great promise, but their precise status is not definitely established as yet. They have been surprisingly effective in treatment of streptococcus, gonococcus, meningococcus, and urinary infections. They should be used only under a physician's direct supervision. The method by which these new chemotherapentic molecules work is a mystery, the solution of which is a great field for future research.

—C.M.P.

COLBERT, EDWIN H. "A Fossil Comes to Life." *Natural History* 43: 280–283; May, 1939.

Previously believed to have been extinct for sixty million years, an antiquated fish from the age of the Dinosaurs, was recently discovered off the coast of South Africa. Of all living creatures, it shows the earliest evolutionary stage in the development of the human foot and hand, and gives us a glimpse at the closest living relative of our fish-like ancestors. It is considered one of the most important zoological discoveries of the present century.

—C.M.P.

WOOD, KERRY. "Behind the Dam." *Natural History* 43: 290–297; May, 1939.

This is a very interesting article on the activities of beavers in building their homes and obtaining and storing their food supply.

—C.M.P.

LOROUT, MICHAEL. "The Size of the Universe." *Discovery* 200–206; April, 1939.

This is a non-technical discussion that attempts to give some understanding of the size of the universe that will be comprehensible to the layman. There are twelve excellent, pertinent illustrations.

—C.M.P.

WALKER, N. W. GREGORY. "How Stained Glass is Made." *Discovery* 2: 163–169; April, 1939.

This illustrated article describes the modern development of an ancient craft—the making of stained glass windows.

—C.M.P.

ANONYMOUS. "Trick Photos You Can Make." *Better Photography* 2: 5–9, 76–77; February, 1939.

This illustrated article on trick photography will prove interesting to any amateur photographer as well as the general reader who often wonders "how it was done."

—C.M.P.

MCKAY, HERBERT C. "The Truth About Your Camera." *Better Photography* 2: 53–57; February, 1939.

This "test chart" article answers questions that may be answered about the lens in your camera—definition, astigmatism, and coma; exposure tests—underexposure and overexposure; development tests; filter tests; printing tests; and paper grade.

—C.M.P.

HABURTON, RALPH. "Print Faults." *Minicam* 2: 28–29, 79; March, 1939.

An illustrated article discussing common print faults and ways to avoid them. Among these are Newton's rings, finger prints, reversed image, stains, air bubbles, sticking, spots, buckling, dust particles, fogged print, reversal of print, and streaks.

—C.M.P.

HOODLEY, H. O. "Spotting—the Last Step." *American Photography* 33: 350–354; May, 1939.

The last thing to be done before a print is truly finished is spotting. Spotting consists in removing from the print miscellaneous white marks. The spots are removed by adding a pigment of the same color as the print in a concentration sufficient to match the density of the print around the spot. The materials needed are a camel's hair brush, about an inch wide, a spotting brush, and a "spotting color." The easiest paper to spot is one with a smooth matte finish.

—C.M.P.

ANONYMOUS. "Five 'Cardinal Sins' of Amateurs." *Better Photography* 2:20–23; May, 1939.

The five most common faults of the beginner in photography are: (1) failure to stop movement, (2) camera-movement, (3) dirty lenses, (4) poor focusing and failure to allow for parallax, and (5) failure to get close enough and keep pictures simple.

—C.M.P.

ANONYMOUS. "Clouds." *Minicam* 2:13–17; May, 1939.

This article consists mostly of some excellent pictures of clouds taken from the Pickwell book entitled "Weather."

—C.M.P.

WESTON, EDWARD. "Light vs. Lighting." *Camera Craft* 46:197–205, May, 1939.

This article discusses the following three phases of the photographic process: (1) learning to see through your lens, (2) learning to see in terms of your film emulsion, and (3) learning to see in terms of your paper emulsion. Practical applications with illustrations are included.

—C.M.P.

BROWNELL, L. W. "Nature and Wild Life." *American Photography* 33:448–452, June, 1939.

Each issue of *American Photography* has an illustrated section devoted to wild life. This particular issue is devoted to the nests of marsh birds. Much interesting nature comment accompanies the splendid photographs.

—C.M.P.

COLEMAN, W. W. and WILSON, F. J. "Better Bird Pictures." *Camera Craft* 46:262–267; June, 1939.

This illustrated article offers some excellent advice to those interested in bird photography.

—C.M.P.

KEMP, DONALD C. and LAITSCH, CHARLES E. "Timberline." *Camera Craft* 46:256–261; June, 1939.

This article includes some excellent photographs of timberline trees, especially suitable for biology and general science classes.

—C.M.P.

MASLOWSKI, KARL. "Frogs A-Wooing Go." *Minicam* 2:46–51, 72–75; June, 1939.

This is an interesting article on frogs, illustrated with some excellent photographs.

—C.M.P.

DAVIS, EMILY C. "The Sphynx Tells All." *Science News Letter* 35:378–380; June 17, 1939.

Excavations by Selimbey Hassan of the University of Cairo has dispelled much of the mystery about the sphynx. It develops he is no lady, so he has revealed his age—an age dating back to 2700 B.C.

—C.M.P.

ANONYMOUS. "Frozen Sleep May Replace Ether and Other Anesthetics." *Science News Letter* 36:84; August 5, 1939.

Cold hibernation may replace anesthetics in operations in the future. Such treatment has already been used in inoperable cancer cases.

—C.M.P.

ANONYMOUS. "Super-Heavy Elements May Be Stuff of Dense Dwarf Stars." *Science News Letter* 36:35; July 15, 1939.

Dense dwarf stars may be composed of super-heavy elements with atomic weights up to 26,000, rather than composed of neutrous as is assumed often. The splitting of these super-heavy atoms would afford a source of cosmic rays, whose origin is one of the great mysteries of science.

—C.M.P.

ANONYMOUS. "Cubic Inch of Dwarf Star Weighs 18,000,000 Pounds." *Science News Letter* 36:51–52; July 22, 1939.

Wolf 457 is a dwarf star with matter so dense that a cubic inch of it weighs 9,000 tons. Eighteen white dwarf stars are known.

The most tremendous phenomenon known to man is the exploding of supernoval, of which thirty are known to have occurred—one very recently. A supernova may have the luminosity of 70,000,000 suns. If a supernova happened in our own Milky Way it would easily be visible in the daytime.

—C.M.P.

DAVIS, WATSON. "Glass from Coal." *Science News Letter* 36:106–107; August 12, 1939.

Organic glass, plastics, or synthetic resins made from coal, or oil, water and air may rival or surpass the present-day glass from sand. The new organic glass can be used for jewelry, window glass, eyeglasses, lenses for cameras and so on. It is lighter, less brittle, and more flexible than ordinary glass.

—C.M.P.

New Publications

REH, FRANK, and WHEAT, FRANK M. *Science and Life.* New York: American Book Company. Book I, 1938. 195 p. $0.76; Book II, 1939. 249 p. $0.76; Book III, 1939. 249 p. $0.96; Book IV, 1939. 482 p. $0.96; Book V, 1938. 320 p. $1.16; Book VI, 1939. 650 p. $1.16; Book I and II Combined $1.20; Book III and IV Combined $1.48; Book V and VI Combined $1.80.

This interesting set of books is adapted to the three years of Junior High School. There are single books for each semester or combined books for the entire year. This is of advantage in those schools where each year's work is divided into half-year subjects. The usual fields of subject matter are well covered. The language is simple; well within the understanding of the children. The illustrations are particularly commendable; many of them are of the cartoon type which are pleasing to the children.

—W.G.W.

CARROLL, FRANKLIN B. *Interpreting Science.* Philadelphia: John C. Winston Company. *Understanding Our Environment,* 1939. 438 p. $1.48; *Understanding Our World,* 1939. 554 p. $1.56; *Understanding the Universe,* 1939. 712 p. $1.68.

This three-volume series of science books covers the generally accepted content material for use in the Junior High Schools or grades 7, 8, and 9. The author begins with pupil experience within his own environment and broadens the pupils horizon, eventually, to the whole universe. The treatment is the type that challenges pupils interest. The work is organized into units which are divided into chapters. The story of each chapter is told, then follows a list of experiments, either for pupil use or class demonstration. The books have excellent illustrations, a number of which are in color.

—W.G.W.

JAQUES, H. E. *Living Things How to Know Them.* Mt. Pleasant, Iowa: H. E. Jaques, 1939. 164 p. $1.00.

This is a guide for beginners as well as a valuable reference for more experienced biologists. There is an illustrated key to the phyla, classes and more important orders of plants and animals, with suggestions for studying them. More than 700 different species of plants and animals are attractively pictured.

Elementary science, general science, and secondary biology teachers will find the book very practical and useful. More than 100 biology projects are described. *Living Things* is an excellent companion-volume to the author's earlier *How to Know the Insects.*

—C.M.P.

CONKLIN, GROFF. *All About Houses.* New York: Julian Messner, Inc., 1939. 194 p. $2.00.

This is the story of the building of a house. There are a total of 369 photographs illustrating specific points. Any science teacher will find here interesting information that he can use in his classroom work. It would seem to be an especially valuable reference in Consumer courses in science and the more recent fusion courses. Problems in plumbing, wiring, insulation, making concrete and plaster, heating, and so on, are discussed. Science teachers so often have no practical specific information along these lines, and yet such information would add so much to the teaching efficiency of certain units in science. In fact there is a real need for such a book for science teachers and pupils.

All About Houses partially answers this need. Most science teachers will know more about the houses in which they live after reading this book!

—C.M.P.

ESKEW, G. L. *Guinea Pigs and Bugbears.* St. Louis, P. O. Box 301: Research Press, 1938. 272 p. $2.50.

In a court case, this book might well be entitled *For the Defense,* because it presents the other side of the case relating to the series of books issued by Consumer's Research, e.g. *100,000,000 Guinea Pigs, Skin Deep, Partners in Plunder,* and so on. In all fairness, this book should be read by all those who have read the Consumer's Research books referred to above. *Guinea Pigs and Bugbears* attempts to "debunk the bunk" put out in these earlier publications. The author cites the many inconsistencies of the Consumer publications, pointing out they have an axe to grind, and that the laboratory testing facilities on which Consumer's Research base their recommendations and condemnations are actually nil. One of Eskew's main arguments is that Consumer's Research never has, and cannot now, make adequate tests on all the products they so glibly recommend or condemn. In other words, Consumer's Research is in operation for the sole benefits of the owners who are paid handsome royalties for their meager researches. America has had many other similar agitations in many fields in recent years, whose only real purpose was to provide handsome salaries for the few promoting the agitation. Eskew really puts up an excellent defense and the present juror (reviewer) could not honestly vote for the

opposition. It is probable that the truth lies somewhere between the two extreme positions taken, but much nearer the viewpoint taken in this book. These books only go to show that it is almost if not impossible to arrive at the truth about any given situation, which does not involve strictly scientific experimentation.

—C.M.P.

BAKER, A. O. and MILLS, L. H. *Dynamic Biology.* Chicago: Rand, McNally and Company, 1938. 738 p. $1.80.

Dynamic Biology presents a fascinating story of animal and plant life. It gives a fair amount of space to man. It contains a wealth of source material for nature study. It is organized into units subdivided into problems. Each unit opens with a preview, and ends with suggested activities. It is beautifully illustrated and has a dozen full-page color plates. The appendix gives an outline for the classification of plants and animals, a bibliography, and a glossary.

The same authors have prepared a workbook to accompany the text. It is called *Activities for Dynamic Biology.* This has 218 pages. The activities, in the main, consist in the pupil writing down answers to a series of questions relating to each problem. The answers in some cases are found by reading the text; in other cases by observation of laboratory specimens, demonstration or on field trip. At the end of each unit is a self testing exercise.

—W.G.W.

TIPPETT, JAMES S. *Henry and the Garden.* Yonkers, N. Y.: World Book Company, 1939. 46 p. $0.24.

This is a beginner's book in reading, built around a science theme. On each page is a colored photograph with interesting textual material. Particular attention has been paid to the vocabulary. Altogether it is a most appealing book.

—C.M.P.

DULL, CHARLES E. *Modern Physics.* New York: Henry Holt and Company, 1939. 613 p. $1.80.

This book is a complete revision of a popular text first published in 1934. This book represents quite a contrast to the earlier book. The author has utilized the following method of approach: (1) The topic is stated or a question is raised, (2) Some incident with which the pupil is familiar is used as an introduction, (3) The physical principle is then discussed or explained, and (4) The manner in which the principle is utilized is shown by the use of one or more applications.

The organization is that of the unit type, having twelve units as follows: (1) Matter and Mechanics, (2) Molecular Physics, (3) Force and Motion, (4) Work, Power, Energy, (5) Machines, (6) Heat, (7) Sound, (8) Light, (9) Magnetism and Static Electricity, (10) Current Electricity, (11) Radio and Radiations, and (12) Transportation.

There are numerous line drawings, illustrations, and photographs. The larger page size and the use of double columns should add to reading comfort and speed. Technical words are defined at the beginning of each unit. —C.M.P.

WALTERS, GARNETTE and COURTIS, S. A. *A Picture Dictionary for Children.* New York: Grosset and Dunlap, 1939. 478 p. $1.25.

This is a dictionary for the very young child—planned for the "learning to read" child. There are 1,200 illustrations and 4,832 words. Each word is both printed and written, and is illustrated with a picture and a descriptive sentence. Special care has been taken to present words by pictures, comparisons, context, print, and script in ways that make it possible for very, very young readers to find meanings for unfamiliar symbols, to discover new words related in meaning, and spelling to known words. Elementary science teachers and parents will find this a useful book to have in the classroom. It really represents a progressive step in educational teaching methods. It should help the child to help himself develop in him the dictionary habit, create greater interest in reading and learning, and result in a much larger vocabulary. Many children will find the use of this dictionary real fun.

—C.M.P.

HAUSRATH, ALFRED H., JR. and HARMS, JOHN H. *Consumer Science.* New York: The Macmillan Company, 1939. 692 p. $2.40.

The subtitle of this book, *A Fusion Course in Physical Science Applied to Consumer Problems* indicates the scope of this book. This is the third such book reviewed in *Science Education.* It is intended for the upper high-school level. The content is based upon the authors' seven years experience with such a course in the Ames Iowa High School. The authors believe that science should be a must subject for all high school students, but that the usual chemistry and physics courses should not be required of all students.

The authors have attempted to make the book "a working combination of unit method, intrinsic interest, pupil-centered learning, purposeful study and activity, integration, fusion, and social science." There are six units as follows: (1) Understanding Science, (2) Living with Machines, (3) Everyday Electricity, (4) Applied Chemistry, (5) Applying Consumer Science, and (6) Science and the Welfare of Man.

Mathematical applications and problems have been kept to a minimum. Stress is laid on the scientific method. Each unit has an interesting list of preliminary questions, a list of useful references, application problems, summary problems, and supplementary activities.

Many more books such as this one will appear with an ever-increasing tempo. As yet the con-

tent is in a process of evolution as was general science in its earlier days. This book represents a very good beginning.

—C.M.P.

FRANCIS, CHARLOTTE A. and MORSE, EDNA C. *Fundamentals of Chemistry and Applications.* New York: The Macmillan Company, 1939. 542 p. $3.00.

The scope of this book is described as chosen from inorganic, organic, and biochemistry with applications in everyday concerns and in the applied sciences including physiology, cookery, bacteriology, and materia medica.

The authors are instructors in chemistry in Teachers College, Columbia University. The book is based upon their experiences in teaching beginning College Chemistry to students in nursing and in home economics. The book would seem well adapted for such a course and for such students. Undoubtedly this book will fill an urgent need. The book would serve as an excellent reference for the high school chemistry teacher.

—C.M.P.

WILSON, SHERMAN R. and MULLINS, MARY R. *Applied Chemistry.* New York: Henry Holt and Company, 1939. 530 p. $1.72.

Believing that college preparatory students have no vested rights in chemistry or physics, the authors have prepared this book for students not intending to take college courses in chemistry. Mathematical and overly technical phases have been kept to a minimum and a real attempt has been made to make chemistry vitally interesting. In the opinion of the reviewer they have done a highly successful job. Any student worthy of being given a graduation certificate from high school should readily comprehend the subject matter included. The material has more than the usual every-day applications. There are sixteen units as follows: (1) Introduction to Applied Chemistry, (2) Water and Its Components, (3) The Atmosphere, (4) Fire and Fuels, (5) Acids, Bases and Salts, (6) The Structure of Matter, (7) Chemical Mathematics, (8) Foods, (9) Textiles, (10) Dyes, (11) Bleaching Agents, (12) Household Cleansing Agents, (13) Disinfectants, (14) Drugs, Poisons and Cosmetics, (15) Building Materials, and (16) Metals and Alloys.

—C.M.P.

HOPKINS, B. S., DAVIS, R. E., SMITH, H. R., MCGILL, MARTIN V. and BRADBURY, G. M. *Chemistry and You.* Chicago: Lyons and Carnahan, 1939. 802 p. $1.80.

This high-school textbook emphasizes the development and use of the scientific method through reflective thinking and problem solving. The material is presented in modern unit organization with emphasis on daily life situations and social implications. Chemical principles, generalizations and interesting applications are stressed rather than minute factual material.

Each unit has a preview, a series of problems, suggested readings, and a list of questions.

The book has many excellent photographs and illustrations and should have a real appeal to secondary pupils. It should prove to be a popular, widely used textbook.

—C.M.P.

FREY, NINA A. *Lasius, The Lucky Ant.* New York: E. P. Dutton and Company, 1938. 93 p. $1.50.

An excellent straightforward and accurate but fascinatingly interesting story not only of ant life, but of associated birds, spiders, aphides, beetles and earthworms. Real ecology on a juvenile level.

—O. E. Underhill.

CAREY, M. C. *The Fireman.* New York: E. P. Dutton and Company, 1938. 32 p. $0.50.

A beginner's reading book which tells about the work of the fireman. Illustrations are colorful.

—O. E. Underhill.

CAREY, M. C. *The Baker.* New York: E. P. Dutton and Company, 1938. 32 p. $0.50.

A charming little beginning reading book telling about the work of the baker and the miller. Good illustrating.

—O. E. Underhill.

SKILLING, WILLIAM T. and RICHARDSON, ROBERT S. *Astronomy.* New York: Henry Holt and Company, 1939. 579 p. $3.00.

This is an extremely happy combination of interesting descriptive astronomy with material sufficiently advanced to serve the college-level student of astronomy. It is exceptionally valuable in that it gives in an understandable way the evidence and the way it is obtained, which supports the descriptive material. The reviewer began to list items which seemed exceptionally well explained but the list soon grew too long to be included. The text itself fulfills to an unusual degree the promise of its preface.

—O. E. Underhill.

How to Organize a Science Club. New York: The American Institute of the City of New York, 60 East 42d St.; 35 p. $0.25.

A philosophy and detailed suggestions for procedure in support of science clubs in relation to school science work. In addition to specific suggestions for starting and organizing such work, there are a classified list of books suitable for a science club library, a key to publishers of science books for youth, a list of magazines and pamphlets for the science club library, equipment put out in the form of toys, science sets, etc., a list of equipment companies, and a sample science club constitution. The publications and equipment lists are well selected and organized.

—O. E. Underhill.

BRUNT, DAVID. *Physical and Dynamical Meteorology.* New York: The Macmillan Company, 1939. 418 p. $6.75.

This is an advanced text in physical meteorology for postgraduate students. It is a thorough treatment of the physical theory underlying weather phenomena and requires a knowledge of calculus for an understanding of the mathematical background.

—O. E. Underhill.

LAW, FREDERICK HOUK. *Civilization Builders.* New York: D. Appleton-Century Company, 1939. 356 p. $1.32.

Biographies of the truly great men of the scientific world, as determined by their contributions to present day civilization, are given in this well organized book.

There are six well named divisions of this book: Transportation, Unifier of Mankind; Machinery, Increaser of Power; Photography, Recorder of Life; Electricity, Worker for Man; Applied Chemistry, Creator of the News; and Medical Advancement, Saver of Life. Each division gives biographies of the men who contributed to that field of the development of civilization. For example in the division on Transportation, there are eleven sections, headed as follows: Humble Beginners of Transportation; James Watt, Inventor of the Condensing Steam Engine; Richard Trevithick, Developer of the Locomotive; George Stephenson, Maker of the First Regular Passenger Train; John Stevens, The First American Railroad Charter; Lincoln, Pullman, and Westinghouse, Contributors to American Railroading; John Fitch, Maker of One of the First Steamboats; Robert Fulton, Perfector of Navigation by Steam; Cugnot, Daimler, and Ford, Developers of the Automobile; Joseph and Jacques Montgolfier, The First Aviators; and Wilbur and Orville Wright, Makers of the First Practical Airplane.

Each biography is written in a very interesting manner. In several of them, the author has used the conversational style of writing. At the end of each division a few pages are devoted to subjects for thoughtful class discussion, subjects for original research and investigation, and books for further reading.

—Roy V. Maneval.

DOORLY, ELEANOR. *The Microbe Man.* New York: D. Appleton-Century Company, 1939. 160 p. $1.50.

Every science student should be interested in this fascinating story of the life of Louis Pasteur. The English author describes even the research of Pasteur so that it is understandable to those who are not familiar with scientific terms. In preparing to write the book, she visited most of the places where Pasteur lived and worked. His life is followed in detail from his birth at Dole, France, in 1822, until the time of his death. His difficulties in acquiring an education and as a scientist are brought out most vividly.

The last two paragraphs of the book give a beautiful tribute to the life of Pasteur—he is still living with us in that we have pasteurized milk, we no longer fear the mad dog, and we have typhoid inoculation.

Interest and authenticity are given to the book by a short introduction by Professor Pasteur Vallery-Radot, the grandson of Louis Pasteur.

—Roy V. Maneval.

BAER, MARIAN E. *The Wonders of Water.* New York: Farrar and Rinehart, 1939. 122 p. $1.50.

Such simple language is used in this book that it could be profitably used by pupils in the upper elementary school. It tells a direct, factual story of water and its many forms—yet manages to bring a gaiety to the telling which clearly shows the freakish character of this ordinary liquid we use daily in a thousand ways.

Some of the interesting chapter titles are: Apple and Boy—Mostly Water; Water Can Push; Water Can't Be Squeezed; Water Takes Many Forms; Crystals; Water Can Work for Man; What Is Water; and Clear But Not Pure.

Parents and teachers will notice the clarity of the text and its simplicity. Any boy or girl will find this book delightful as well as instructive.

—Roy V. Maneval.

HAYNES, WILLIAMS. *Chemical Pioneers.* New York: D. Van Nostrand Company, 1939. 288 p. $2.50.

Many of us fail to realize the pioneering that has been done in order that we might have the great chemical industries of today. This book tells the story of fifteen chemists who have contributed to the building of our civilization. It is the first of two books of biographies of the men chiefly responsible for the establishment of the chemical industry in the United States. The author has included in this book many anecdotes and personal experiences of the men which are not found in the usual biographical account. He has had access to many personal records and company archives to help make the book more interesting and authentic.

The men whose biographies are given are John Winthrop, Jr., George D. Rosengarten, Martin Kalbfleisch, Alexander Cochrane, James Jay Mapes, Eugene R. Grasselli, George T. Lewis, Lucien C. Warner, Edward Mallinckrodt, August Klipstein, E. C. Klipstein, Martin Dennis, Jacob Hasslacher, John F. Queeny, Frank S. Washburn, and Herbert H. Dow.

—Roy V. Maneval.

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